DESIGN AND CONSTRUCTION OF AN ELECTRICAL POWER FAULT CIRCUIT INTERRUPTER

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FEDERAL UNIVERSITY OF TECHNOLOGY
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A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE BACHELOR OF ENGINEERING DEGREE IN THE DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
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ABSTRACT

The system is designed for under voltage and over voltage fault protection. It continuously measures line voltage actual condition in an electrical wiring outlet to a safety limit and disconnects power supply to the load if actual voltage exceeds the limits before they become damage or ignite fire. In certain circumstances, household wiring and appliances have been the source of fires in the home due to over voltage supply, overload and the oxidation of the wire or wear over time.

This involves step down transformer, LM324 voltage comparator that senses input line voltage and generate an output which is connected to the base of 2N2222 PNP transistor. The system also used 555 timers IC for alarm and electromagnetic relay was also used for switching and driving of alarm.

The device detects over and under voltages to the load in the outlet. With this information, voltage comparator is used to evaluate whether a voltage difference exist at the load. When the predetermined voltage threshold is met, the logic switching circuit executes an emergency shutoff so that current to the appliance at that particular outlet is terminated and sound an alarm to notify the user.

TABLE OF CONTENTS

DEDICATION

To God Almighty who makes all things possible and to my late grand parents chief and Lolo Offie Amadi.

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

The demand for electrical energy is a notable feature of modern civilization. The damage done by electricity in everyday life has reached a stage that is desirable to protect lives and properties in our household during fault conditions. Over the year statistic has shown that lives and properties worth of billions naira have been wasted as a result of electrical power fault in homes. Due to this development, improvement in circuit protection devices cannot be avoided as technology advances.

During fault conditions, the current (and heat energy) can increase to the extent that either the appliances burn out or the connecting wires overheat and melt the insulation which can cause electrical fire outbreak. An electrical fire is a fire where electric current or electric fault is found to have been the ignition source [16]. Some of electrical fault are;

- Lighting strike; This is where extremely high voltage and current for few thousandths of seconds, produced some much heat that surrounding materials can catch fire and continue to burn.

- High resistance connections; Household wiring utilizes copper wire that when in contact with moisture and air, will oxidize on contact surfaces. Though electrical wiring incorporates insulation to prevent oxidation, dust, organic compounds and insects and rats pose the risk of deteriorating the insulation to the point where the wiring can be exposed. Contact points at the outlets are also exposed to oxidizing agents. When this occurs, the wire will start oxidizing in the areas where it is exposed. Oxygen is a type of oxidizer that will form an oxide layer on the surface of the wire. As it forms this layer, electrons are stripped from the metal causing the resistively to increase [14]. In addition, loose screw, damaged wires and corrosion causes the physical diameter to decrease. Due to the relationship, $R = \rho \frac{L}{A}$ an increase in the resistivity along with a decrease in the wire's diameter would indicate a decrease in the area (A), causing the resistance (R) to increase. High resistance through a high resistance junction will cause a voltage drop. This project detects the low voltage and disconnects the load to prevent the high resistance junction from heating [16].

- **Over loading**; This occurs when the electric current flowing in the wires exceed the rating of the cable. The wiring heat up and melt the insulation
- **Electrical arching (sparking);** This is where wiring insulation has been damaged by external factor and which lets the conductors inside a cable to touch one another or make contact with the metal case of an appliance.
- **High line voltage**; this can overheat appliances and other electrical devices and causes fire, or simply destroy electronics and light bulbs
- **Low line voltage**; this stresses the switching power supply and thereby causing damage household appliances.

This research looks at how electrical power fault caused by high resistance connections, over voltage and under voltage in our household can be minimized using integrated circuit and discrete electronic components

1.1 Aims and Objectives

The design and construction of electrical power fault circuit interrupter aims at;

- Detecting the line voltage from AC mains
- Drop the voltages proportionally to a window of 0VDC -12VDC from 230VAC
- Compute the voltage difference (if any).
- Terminate current going to the load, if the voltage threshold is reached and trigger the LED and alarm

Benefits

- It has the potentials to save lives and properties
- Reduces the risk of household fires (terminates specific outlet)
- Alerts residents of potential risks
- It has real world application.
- It has high switching speed

1.2. Conceptualization

This was the stage in which the project was conceived. Firstly, it was due to alarming rate of residential fire outbreak in the country. The next step was considering the most effective way of solving this problem and challenges that would be faced were also considered at this stage.

1.3 Consultation

This involves seeking expertise advice about what the project entails in terms of cost and time. Advice was sought from fellow students, lecturers and friends with technical know –how, about how this project could be achieved

1.4 Methodology

The project was carried out by employing the modular design. The circuit is divided into modules and each was analyzed extensively and constructed. Each module is tested and certified before joining all the modules to form complete circuit. The modules considered here are the power supply units, voltage measurement unit, switching circuit, and alarm unit.

1.5 Scope of the project

The concept behind this project is to design and construct a power fault circuit interrupter which allows steady current flow in an outlet during normal circuit conditions and cut off power supply during fault conditions. It senses an input voltage representing the input voltage of power supply, generate a reference voltage, comparing the input voltage with threshold voltage, if it detects low voltage as a result of high resistance connection or over voltage condition when the threshold (reference) voltage exceeds or less than input voltage which might cause potential heating to the wiring, and disables the power supply to the load when aforementioned condition is detected

1.6 Sources of materials

Materials for this project were sourced from various websites, internet, journals, textbooks, and consultation from friends. The components used are purchased locally in the market.

1.7 Brief Description of the project

The electrical power fault circuit interrupter is a protective device in an electrical wiring outlet that measures the line voltage actual conditions to a safety limit and disconnects power supply to the load if actual voltage exceed the limits before they becomes damage or ignite fire. The fault includes high resistance connection and under voltage/over voltage from PHCN.

In this project: the power supply is achieved by using a step down transformer, full wave bridge rectifier to turn AC to DC voltage which is needed to power the circuit. The power fault circuit protection is achieved using Lm324 integrated circuit (IC) which is used as a comparator. It consists of four (4) voltage comparators, of which only two comparators were used. The unregulated power supply is connected to the series combination of resistors and potentiometer. The regulated power supply is also connected to the threshold (reference) voltage potentiometer through variable resistors. Preset potentiometer is adjusted such that normal power supply of 180VAC-240VAC, the voltage of non-inverting terminal (pin3) of lm324 is less than the reference voltage of the inverting terminal (pin2), hence the output of the comparator is zero and the transistor which is connected to the output (pin1) of the op-amp remains off, the relay which is connected to the collector of the transistor remains deenergized. As the AC supply to the electrical appliances is given through the normally closed (N/C) terminal of the relay, the supply is not disconnected during normal operation.

When the line voltage goes below the threshold as result high of voltage drop along the wire, which might be due to high resistance connection or low line voltage supply, the voltage at non inverting terminal (pin5) will be greater than the voltage at non-inverting terminal (pin6), the output of op- amp goes high and energizes the relay through the transistor. Also when the ac power supply goes high above 240, the voltage of the non inverting (pin3) of the comparator increases above the reference voltage of the inverting terminal (pin2), this drives the transistor to energize the relay and alarm circuit.

CHAPTER TW0

LITERATURE REVIEW

2.1 Historical background

Electricity was discovered by Michael faraday (1791-1867). By early 20th Century the use of electricity as source of energy became wide spread .This was largely due to the works of pioneering American engineers and inventors such as Thomas Alva Edison, Nikola Tesla and Charles Proteus Steie met [3].

Electric power can be produced in many ways by conversion of various sources of energy such water; sun, wind, fossil fuel, nuclear energy. Most electrical energy produced today is through hydro-electric plant, nuclear energy and by burning fossil fuel, coal, oil and natural gas. Hydro –electricity system are common in the Nigeria which are generally located in hilly area where dams can be built conveniently and large water reservoir channeled through a control gate and directs water to the blades of hydraulic turbine that produces electricity. The electricity generated from the power house is flows to a transmission station where a transformer changes large current and low voltage into a low current and high voltage. The electricity then flows over a high voltage lines a series of transmission station where the voltage is stepped down by transformer to the levels appropriate for distribution to the final consumer [4, 20]. Electricity is a form of energy which is converted to other forms of energy when it is used to perform a task, and when this occurs heat is generated. Heat is also generated whenever a current flow encounters a resistance to the flow. Voltage normally drops along a wire when current passes through it. The higher the resistance of the circuit the greater the voltages drop. Research has shown that a small voltage drop of 1-5% is expected to drop in all electrical circuit [16]. Excessive voltage drop in a conductor wire is caused by high resistance connection, that is long runs of wire, point of high resistance such as poorly made splices, corroded connection and overload (when wire size is too small to carry the load)[12].

History has also shown that household wiring has been the source of fire outbreak in the due to oxidation of wire or wear over time, overload and over voltage condition [12]. It should also note that protection system is another engineering system design not only to prevent faults, but also to respond to their occurrence and minimize their effects. A wide range of protective devices are available to specific problem at a facility. The method chosen depends on number of factor which cost and efficient cannot be removed.

The history of electrical protective devices is the history of electricity. The earliest and simplest circuit protection device is fuse. The first fuse was inverted by Edison around 1800s [19].It was at this stage that circuit protection devices started having its improvement.

In the 1902 McBride Company started manufacturing fuse link. A fuse is a short piece of metal inserted in a circuit which melts when excessive current flow through it and thus break the circuit .The fuse elements are generally made up of material of low melting point, high conductivity and least deterioration due to oxidation. But the problem with the fuse is that when its element are subjected to deterioration due to oxidation through continuous heating up of its element which makes the current rating of the fuse to decrease [2]. Secondly it has to be replaced after each time of operation.

With the advancement in power distribution systems, the arrangement of switches along with fuse cannot serve the desired function of switchgear especially in a high capacity circuit [7]. In 1904 Cutter manufacturing company located in Philadelphia produces first circuit breaker. It was first called inverse time element [ITE] [18].A circuit breaker is an electrical device cuts off electric current through circuit either manually or automatically under abnormal conditions viz, no load, full load and short circuit conditions. The most familiar household circuit breakers protect circuits against overloading or overheating to prevent fire and electrical short. It also provides protection against short circuits. A short circuit is caused by a contact between the neutral or live side of the electrical line and live side of line. Detoriation of insulation can cause short circuits. Short circuit offer very low resistance to current, which allows large amount of current to flow through the circuit, sometimes melting the wire or causing a fire. Circuit breakers in live side of the electrical line can stop short circuits by cutting the connection when the current get too high [4, 17]. Common household circuit breakers are made up of coil of wire called solenoid and an iron plunger inserted partially inside the solenoid. When the current flows through the solenoid, it produces a magnetic field just as a bar magnet would. The strength of the solenoid's magnetic field depends on the amount of current flowing through it. When the amount of current exceeds the amount that the circuit is designed to hold, the magnetic field in the solenoid is so strong that it pulls the iron plunger completely into the solenoid, breaking contact with the circuit at the end of the plunger and stopping the flow of current. In some circuits, especially those that carrying large currents, simply breaking the circuit is not enough to stop flow of current. The current in some circuits is strong enough to jump, or arc, across the gap in the circuit, even after the circuit breaker has been tripped. Circuit breakers that deal with high levels of current, especially direct current, have methods of getting rid of energy in the arc and stopping the current. These characteristics of circuit breaker have made it useful equipment for switching and protection of various parts of power system distribution [4].

In 1921, Merlin Gen manufactured first high voltage oil circuit breaker. In oil type of circuit breakers, the design of the circuit breaker forces the arc of broken circuit through a sealed container of oil or gas. Air-blast circuit breakers send the arc through compressed air, which is immediately released to the outside, carrying the heat and energy of the arc with it.

The first circuit breaker to be used in household [low voltage] circuit breaker was manufactured in 1951 by Square D manufacturing company. These are miniature circuit breaker [MCB] and molded case circuit breaker [MCCB]. The disadvantages of using circuit breaker is that they do not offer effective fast switching protection of electronic appliances as they only offer protection in the event of short circuit and not voltage drop due to high resistance connections[18].

The present technological dispensation has changed the voltage stabilization and protection techniques greatly. It came up with another approach known as regulated DC inversion approach .This uses the principle of switch mode power supplies. The regulated DC output from power supply is inverted using push-pull inversion and stepped up to required constant AC output voltage using a transformer. It uses zener diodes and potentiometers for voltage protection. The output of the system is a square wave AC voltage which could be filtered to obtain a pure sinusoid. This method produces good regulation and protection. The system is usually not small but very expensive to construct than other systems [5].

Phase controlled voltage regulator is another attempt towards realizing a good regulated voltage [19]. In this system, the load is connected in the series with the voltage

In December, 2004 lee, chun-yan (hsinchu,tw) inverted an over voltage protection circuit[21]. His invention relates to an IC package substrate with over voltage protection function, more particularly, to a single IC package with a structure having multiple over voltage protection devices. In order to protect the IC device, several over voltage devices were subsequently proposed. However, those over voltage protection devices needed to installed individual protection devices on a printed board according to the actual necessity after the IC device was manufactured and installed on the printed. Moreover, such design has the disadvantages of high cost, wasting of limited space, requires installing independent over voltage protection devices to prevent respective IC devices from being damaged by surge.

The advances in fabrication of discrete electronic components have led to reduction in their cost and sizes which give better switching performance than the electromechanical devices earlier considered. One of the latest developments is the use of power fault circuit interrupter which uses discrete electronic components to prevent potential electrical fire in our household under fault conditions. Being solid-state devices, there are no moving parts to wear out, and ability to switch on and off much faster than any electromechanical relay armature can move. There is no sparking between the contacts, and no problems with contacts corrosion [21].

The power fault circuit interrupter presented here is a low cost and reliable circuit for protection of premise house wiring, domestic appliances refrigerators, televisions, etc from damages posed by voltage fluctuations. It uses potentiometer to set the reference voltages for the fault conditions, a comparator Lm324 integrated circuit to compare the input voltage with reference voltage, switches the transistor on and off or energizes\de-energizes the relay in accordance with voltage condition. Whenever the circuit is switch on and load is connected to it, it maintains steady supply to the load during normal conditions and cutoff power supply during abnormal conditions. It senses an input voltage representing the input voltage of power supply, generate a reference voltage, compares the input voltage with reference voltage, detect whether there is a fault condition due to high resistance connection as a result of aging of the wire or over-voltage supply, that is when the reference voltage exceeds or is less than the input voltage, and disables the power supply to the load and triggers an alarm. The circuit is not expensive and not bulky, it easy to construct, has high switching speed and ability to alert the user during fault conditions.

CHAPTER THREE

DESIGN AND IMPLEMENTATION

This chapter deals with the design methods and analysis employed in the design of an Electrical Power Fault Circuit Interrupter [PFCI]. These analyses are required to make the correct choice of component values for effective performances. The electrical power fault circuit interrupters designed in this project is divided into the following modules;

- Power Supply Unit
- Voltage Measurement (control) Unit
- Switching Unit
- Alarm Unit

The block diagram of power fault circuit interrupter is shown in figure 3.1

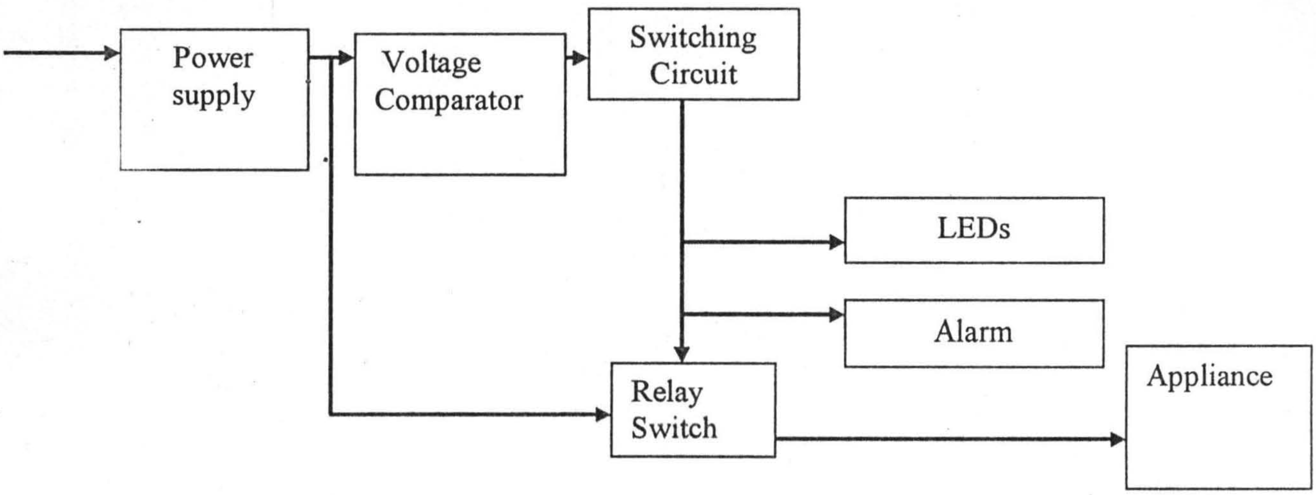


Fig 3.1 Block diagram of power fault circuit interrupter

3.1 The power supply unit

The power supply unit comprises of the following

- Power transformer.
- Full-wave bridge rectifier
- filtering circuit
- Voltage regulating circuit

The block diagram of power supply circuit is shown below

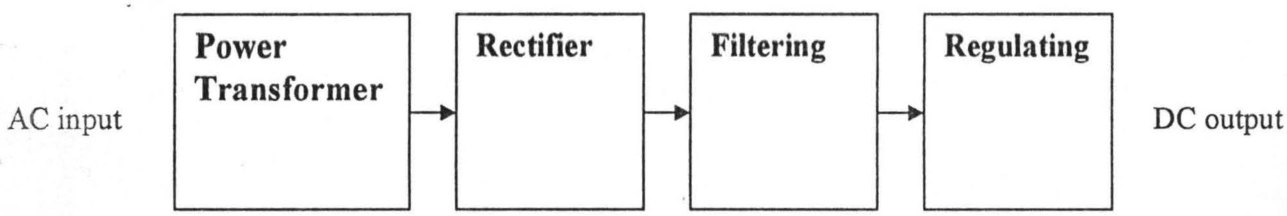


Fig. 3.2 Block diagram of power supply unit

3.1.1 Power transformer

A transformer is a static (or stationary) piece of apparatus by means of which electric power in one circuit is transform into electric power of the same. It consists of two closely coupled coils called primary and secondary coils. An AC voltage applied at primary coil induces a voltage in the secondary coil

Since the DC voltage required for operation of active components used in this project is 12VDC, a transformer of 240V-12V, 0.5A is used for the design of power supply circuit

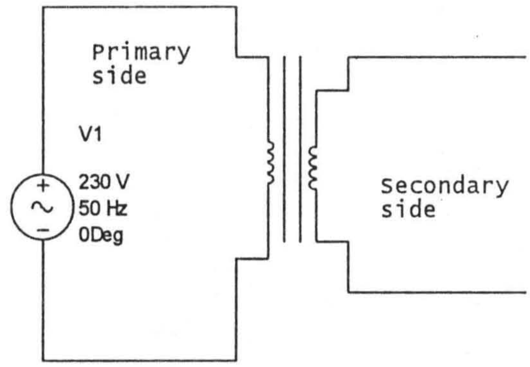


Fig 3.3. An ideal transformer,

Vp Ip = Vs Is...3.1

Vs = voltage delivered at secondary coil.

VP = voltage applied at primary side.

Is = current delivered at secondary coil

Ip = current drawn by the primary coil

3.1.2 The rectifier circuit

This circuit converts the transformer AC output to DC power supply. In this design full wave bridge rectifier which uses four diodes working alternatively. Both cycles of alternately waveform are utilized. The diagram of bridge rectification is shown below

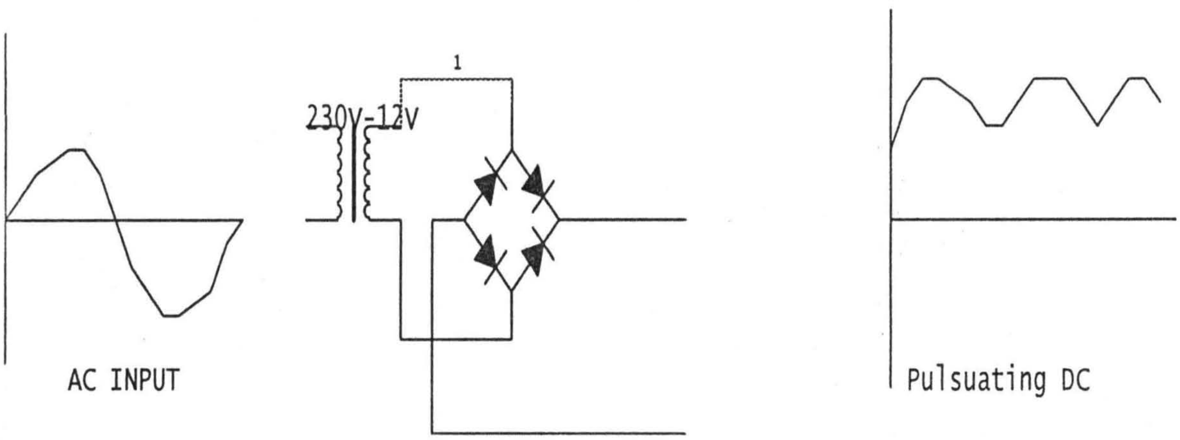


Fig 3.4 is the circuit diagram of Bridge rectifier

3.1.3 The filter circuit

The output of the rectifier circuit in fig 3.4 is pulsating. It has a DC value and very significant AC components called ripples. The filter circuit consists of a capacitor [reservoir condenser] and is necessary to minimize the ripple content in the filter output. The capacitor charges up during the diode conduction period during peak secondary voltage and discharges through load when the rectifier voltage falls.

The filter capacitor was selected based on ripple factor, peak inverse voltage of Vrms of the transformer.

Peak inverse voltage (PIV) for bridge rectification = $\sqrt{2} \times \text{Vrms}$

PIV = $\sqrt{2} \times 12 = 17\text{V}$..3.2

Id =500mA

Vrms =12Vrms

Ripple factor = 0.08

VR =Ripple voltage =Idc\(c*2*f)..3.3

F =Main frequency = 50Hz

VR= 0.08*12 =1.92v...3.4

1.92v = $(500*10^{-3})\backslash(2*c*50)$..3.5

C = 2200µf.

From the above calculation 2200µf, 25V is used as filter capacitor which is above the peak inverse voltage.

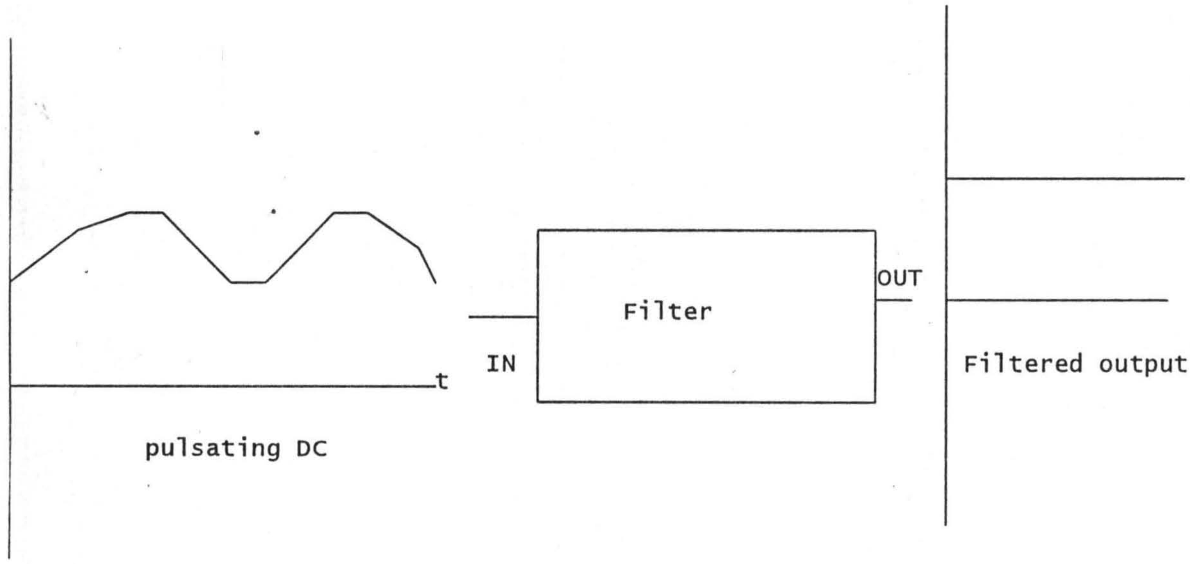


Fig3.5 AC component in DC supply

3.1.4 Voltage regulator

Voltage regulator comprises a class of widely used ICs. Regulator IC contains the circuit for reference source, comparator, control electrical overload protection all in a single

IC. Although the internal construction of the IC is some what different from that of the discrete components circuits, the external operation is much the same.

In this project, the Lm 78xx (series voltage regulator) was used.

The Lm78xx series of three terminal regulations is available with several fixed output voltage making them useful in a while range of application. the voltage available allow these regulators to be used in logic systems, instrumentation,HIFI and other solid state electronic equipment [10]. Output voltage other than 5V, 12V and 15V the LM117 series provides on output voltage range from1.2V to 57V.

Feature includes; Output current in excess of 1A, internal thermal overload protection, no external component required, output transistor safe area protection, internal short circuit current limit and available in the aluminum To – 3 packages.

Voltage Range; LM7805C 5V, LM7812C2V and LM7875C BV

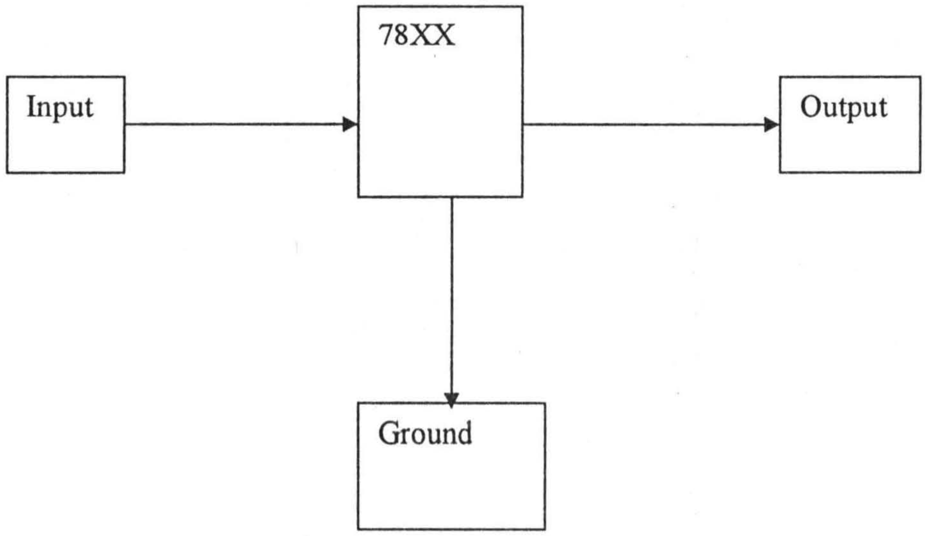
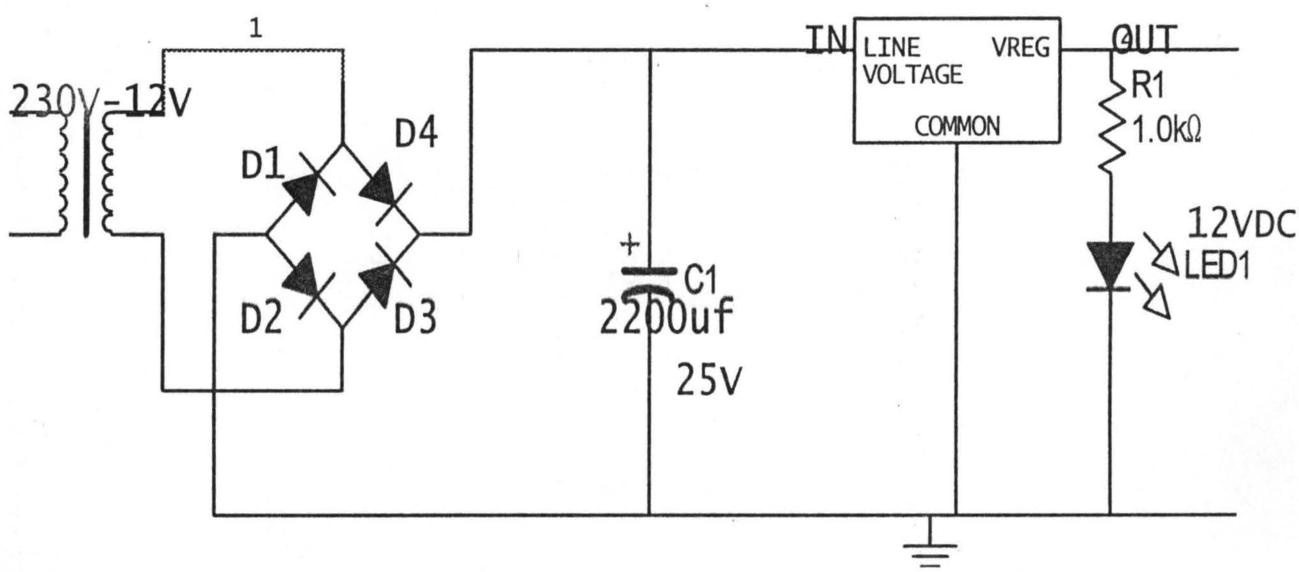


Fig 3.6 Schematic diagram of voltage regulator

Since the active components in this project required 12VDC, Lm7812 voltage regulator was used as the circuit regulator. The complete circuit of power supply is shown in fig 3.7.



D1=D2=D3=D4=IN4007

Fig 3.7 Complete circuit diagram of power supply unit

3.2 Voltage measurement unit

3.2.1 The voltage comparator

In electronic, a comparator is a device which compare two voltages or currents and switches its output to indicate which is larger, that is it looks at two input signals and switches its in output accordance with the input. A comparator is similar to an op-amp because it has two input voltage (non-inverting and inverting) and one output. It differs from the op-amp circuit because it has no negative feedback and it has two states output, either a low or a high voltage. Because of this, comparators are often used to interface with analog and digital circuits. A dedicated voltage comparator will be generally faster than a general-purpose op-amp pressed into service as a comparator. A dedicated voltage comparator may also contain additional reference and a single threshold point (no hysteresis) [11].

3.2.2 Dedicated voltage comparator chip

A dedicated voltage comparator chip, such as LM324, is designed to interface directly to a digital logic (for example TTL or CMOS) the output is in binary state, and it is often used to interface real world signals to digital circuiting. If one of the voltage is fixed, for example because a DC adjustment is possible in a device's earlier signal path, a comparator is just cascade of amplifiers. For high speed the same techniques as in binary logic be applied to avoid deep saturation of the amplifiers, which would otherwise lead to long recovery times. Also like in binary logic the speed is not as high as if the amplifiers would be used for analog signals. Slew rate has no meaning for this device.

This makes the output of this device very flexible it can be used to drive many kinds of logic

The LM324 consist of four independent precision voltage comparator with an affect voltage specification as low as 20MV Max for each comparator, which were designed specifically to operate from a single power supply over a wide range of voltage operation from split power suppliers is also possible and the low power supply current chain is independent of the magnitude of the power supply voltage.

This comparator also has unique characteristics that the input common-mode voltage range include ground, even through they are operated from a single power supply voltage. The LM324 TTL and CMOS, when operated from both plus directly interface with CMOS where their low power drain is a distinct advantage over standard comparator (12)

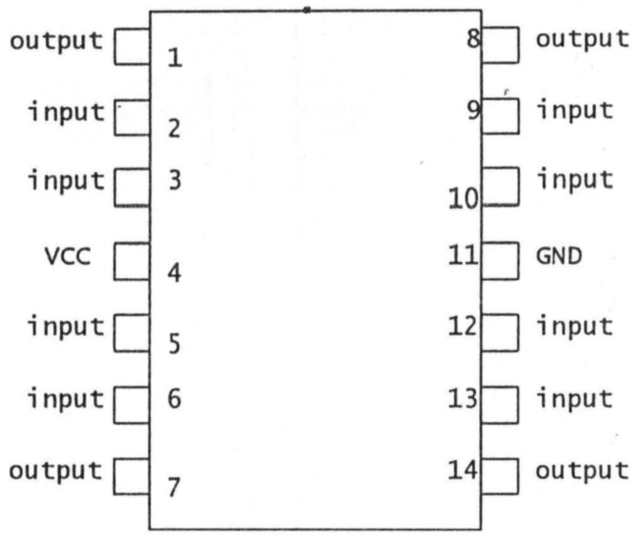


Fig3.8 Pin configuration of the LM339 comparator

3.2.3 Calculating threshold voltage

When determining the voltage threshold, several assumptions and consideration was made. The first thing for example considered was the type of wiring typically found in households. Since residential buildings incorporate 20Amp breakers, the wiring required would have to be 12 gauges. The gauge refers to the physical size of the wire. Different gauges have various temperature rating. When analyzing a 12 gauge wire, the temperature range found was between (480 – 600) degree Fahrenheit [13]. In order to make calculation with these temperature values, the weight of the wire would be needed as well. For this project the wire length considered is 25feet, the corresponding weight is roughly 0.5ibs [14]. To account for safety, the minimum temperature rating of 480 degree Fahrenheit is used as the threshold at which the wire would start to burn with the assumption that the average household temperature is 75degree Fahrenheit the following equation was used to calculate the amount of heat produced when the wires temperature increase from (75 – 480) degree.

$$Q = (0.094m\Delta T) \qquad \text{.......... 3.6}$$

The value of (0.094) is the specific heat of copper puzzling in the weight (m)to be 0.5lbs and change in temperature (4480 – 75 degrees).

$$Q = 19.035BTU$$

To determine the power consumed over a period of one minute due to the temperature change.

$$P = \frac{Q/\min}{\frac{56.89BTU}{IKW\,Mi}} = \frac{19.035BTU/\min}{\frac{56.89BTU}{IKW\min}} = 3346KW \qquad \text{.......... 3.7}$$

Making the assumption that some appliance draws on average 15AMPs, the following relation was derived in equation

$$Vdrop = \frac{p}{i} = 3346 \qquad \text{.......... 3.8}$$

Therefore, taking the nominal to be 230VAC, therefore. A voltage drop of 22.31v would yield to threshold voltage of V threshold V=230-22.31=207.69V.

From the above calculation 180V was chosen as the minimum Voltage and 240V as the maximum for normal operation, while any voltage below 180V or above 240V will considered as under voltage and over voltage respectively for fault conditions

3.2.4 **Rheostat setting for voltage control circuit**

The voltage for under voltage and over voltage level was set as 6.0 and 6.8 respectively. This necessitates the choice of the potentiometer and their values were used based on the voltage divider network depicted in fig3.9. and 3.10

3.2.5 under voltage divider network

The circuit comprises of a resistors, potentiometer and a comparator. R1 and R2 limit the current flowing in the potentiometers. Zener diode is used to set Vreference voltage to 6V while VR1 is what vary the supply voltage. At any input voltage less than reference voltage, a the fault condition of high resistance, and under voltage condition will occur, then the comparator gives a higher output when unregulated input is less than the reference voltage (Vunreg< Vref), the output takes on the 12V that is interfaced to π logic. A yellow LED is connected at output of the comparator to indicate the above faults. Then 1kΩ resistor is used to limit the current flowing to the switching unit. The figure shown below is the circuit diagram of the higher resistance under voltage condition voltage divider network

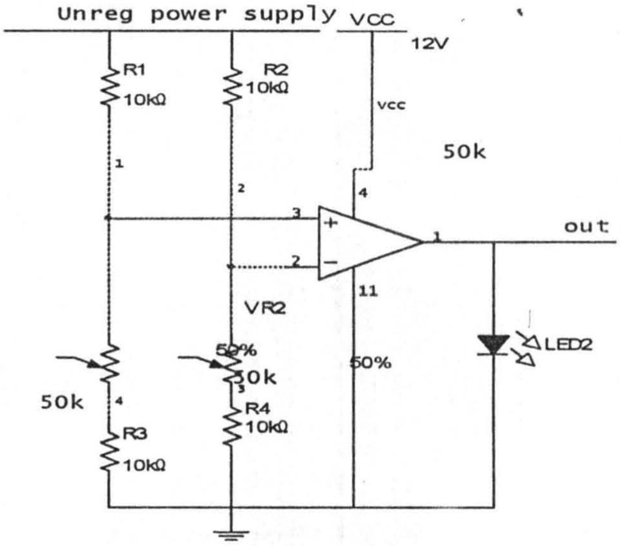


Fig 3.9 Voltage divider network for under voltage fault condition

3.2.4 Rheostat setting for voltage control circuit

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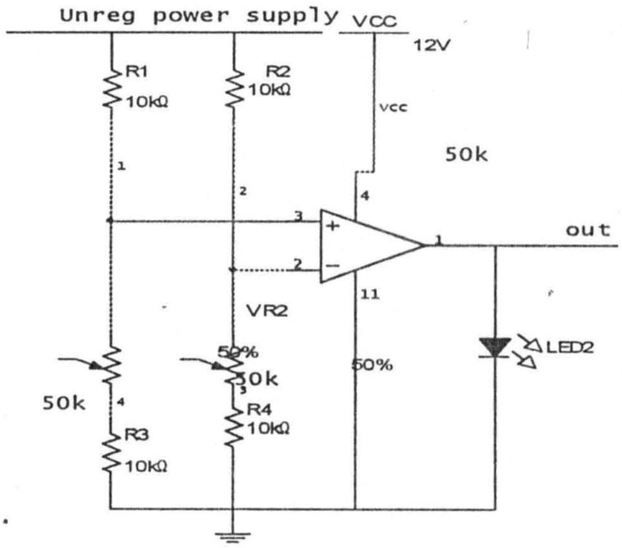


Fig 3.9 Voltage divider network for under voltage fault condition

3.2.6 Over voltage divider network

The over voltage control circuit comprises of a resistor, potentiometer and a comparator. R4, R5 limit the current flowing in the potentiometer VR4 is a variable resistor and it is used to set reference voltage to 6.8v while VR3 what vary the supply voltage to the comparator. At any input voltage greater than reference voltage, the gives high output indicating over voltage fault condition . A red LED is used to indicate the above fault. Then, 1kΩ resistor is used to limit the current flow to the switching unit.

The Figure shown below is the circuit diagram of the over voltage control unit.

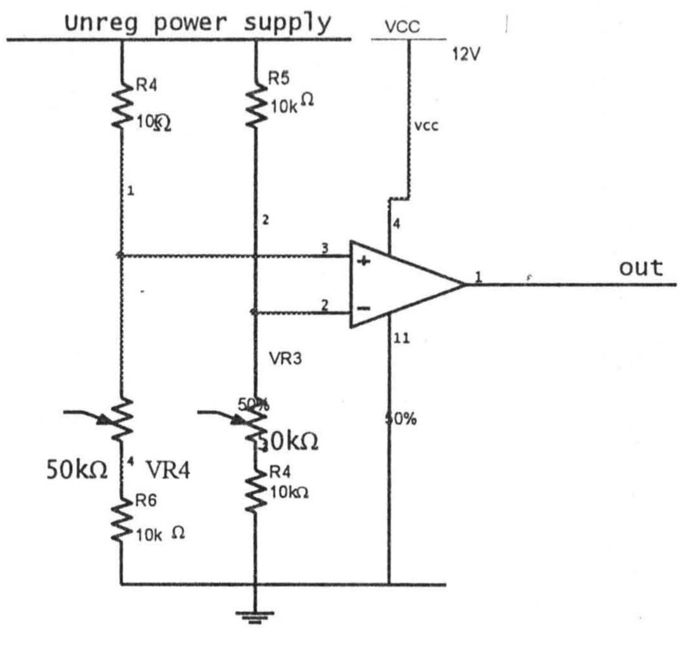


Fig 3.10 Voltage divider circuit of over voltage fault condition

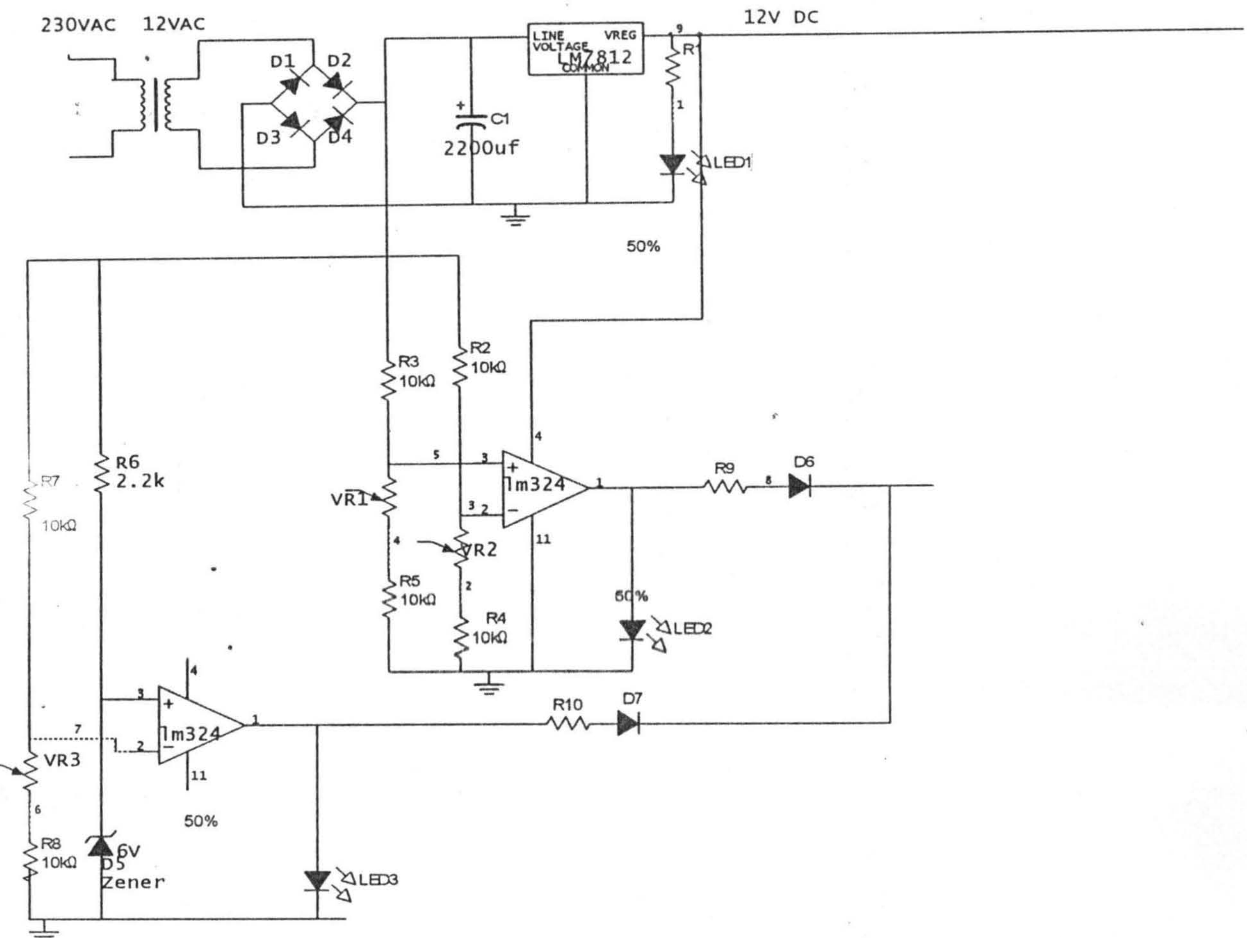


Fig 3.11 complete circuit of Voltage measurement circuit

Summarily, the reference voltage can be adjusted to any voltage level based on the power supply fault the user wish to control, that is

(i) For normal operation the supply voltage should be greater than the reference voltage for the under voltage condition and less than over voltage fault condition

(ii) For under voltage or high resistance connection which causes large voltage drop on premise house wiring, the potentiometer was adjusted such that the reference voltage is greater than the supply voltage (Vref > Vunreg)

(iii) For over voltage fault condition, the potentiometer was adjusted such that the supply voltage is less them the reference voltage (i.e. Vunreg < Vref)

This makes the comparator total control of the voltage level such that household appliances are turned ON during normal operation and switch off during fault condition.

3.3 Switching circuit

The switching circuit is made up of a network PNP transistor (2N2222), an electro mechanical relay, diode and current limiting resistors.

The transistor used in the switching network is a high speed switch 2N222 and it has the following properties:

It is a silicon plainer Expitaxial PNP in Jedec T0-18 9 (2N222π) metal case. They are designed for high speed switching application at collector current up to 0.5A, and has current gain over a wide range of collector current, low leakage currents and low saturation voltage. The following values were calculated for the resistor. From the data sheet [10], the following Parameters were deduced:

Vbe=0.6V

Vout= comparator output voltage =12V

Ib= 12mA, Ic= I5mA

From the above relationship;

Lb= (Vout-Vbe)\Rb……………………………………………………………………3.9

Rb= (Vout-Vbe)\Ib……………………………………………………………………3.10

Rb= (12-0.6)\0.012

Rb= 950Ω

From the above calculations, a resistance of 1kΩ was taken for the base resistors. Two diodes, D5 (IN4007) and D6 (IN4007) are also connected to the base of the transistor to prevent feedback between the two output from the comparator to the transistor.

The collector of the transistor was connected to the 10A 12V, relay. A "free wheeling" diode D_8 (IN4007) was also connected between the relay and the collector of the transistor to prevent 'back emf' from damaging relay from the transistor.

The relay is connected to the home appliance in the normally closed (N\C) configuration so that whenever faults occur, the relays is energized and switch its configuration to normally open (N\O) and the load (i.e. the appliance) is disconnected from the power supply.

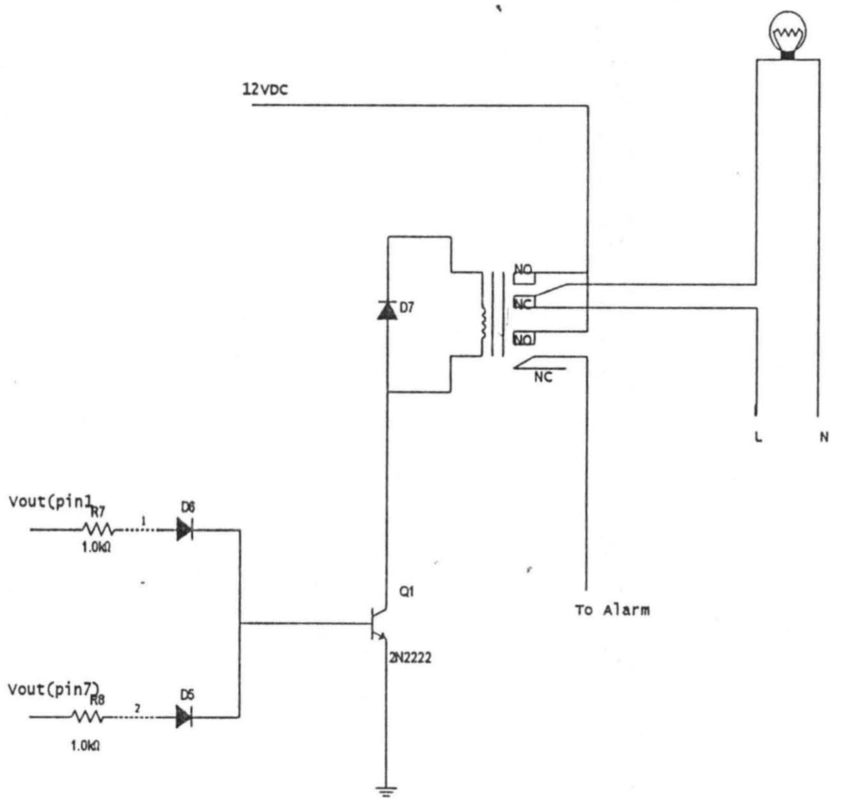


Fig 3.12 switching circuit

3.4 Alarm unit

The alarm unit of power fault circuit interrupter was a achieved with aid of low voltage NE555 timer which generate sound wave of frequency ranging from less than 1Hz to 500KHz with duty cycle of 1to 99 percent[7,20]

3.5.1 Switching network of alarm unit

The alarm is activated by the fault condition of the power supply (either as result of high resistance\under voltage or over voltage conditions. To provide for efficiency and fast switching during fault conditions, the outputs of the comparator (pin1) and pin7) was connected to a transistor and the collector of the transistor was also connected to the relay. The normally opened side of the relay is connected to the Vcc and normally closed of the relay is connected to the pin8 of the 555 timer which is the Vcc. The combinations of resistors and capacitor to produce an oscillation that is needed to drive the buzzer thereby producing alarm during fault conditions

During fault conditions the output of the comparator pin1 and pin7 will go high , thereby de-energizing the relay from normally closed (NC) to normally opened (NO) condition thereby disconnecting the load and the normally opened relay energize thereby activating the alarm .The circuit diagram of alarm unit is shown in figure 3.13

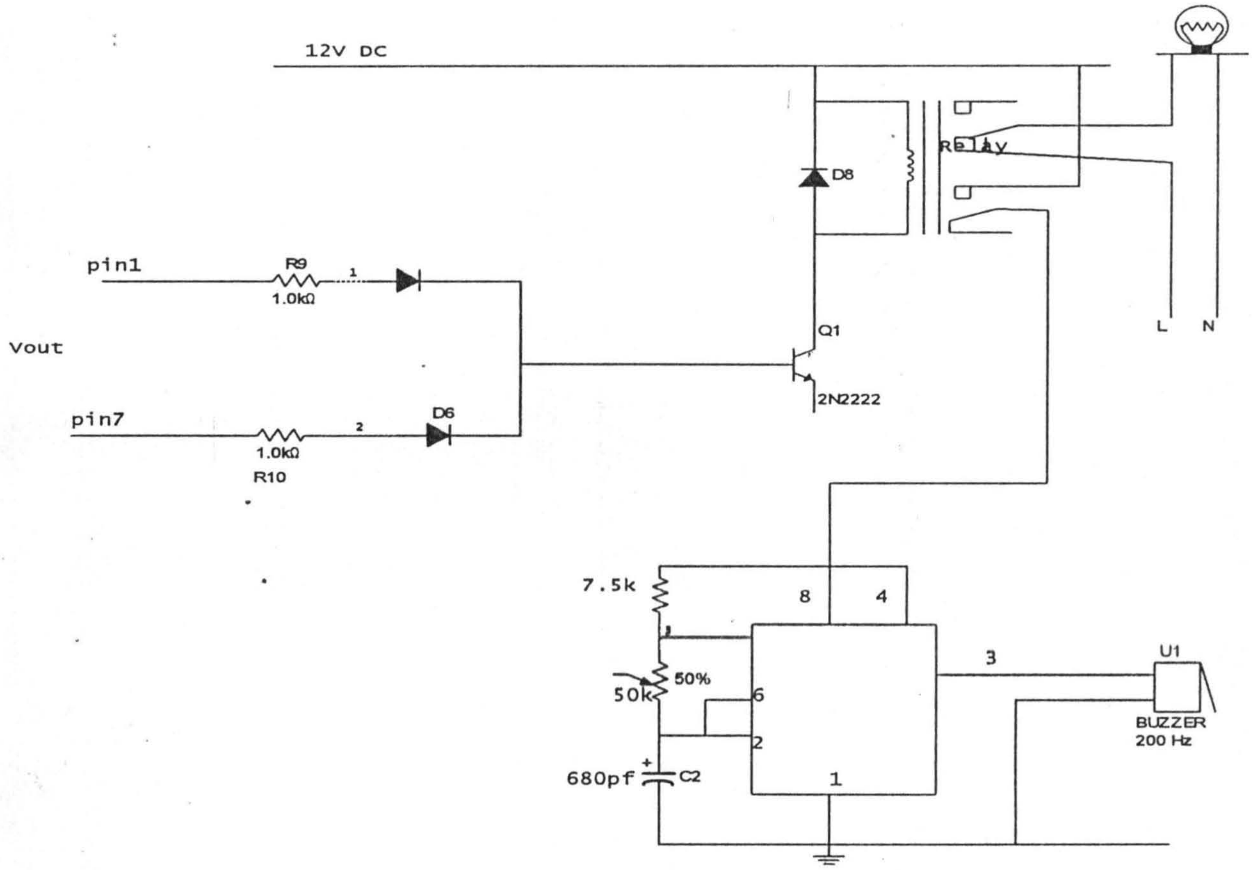
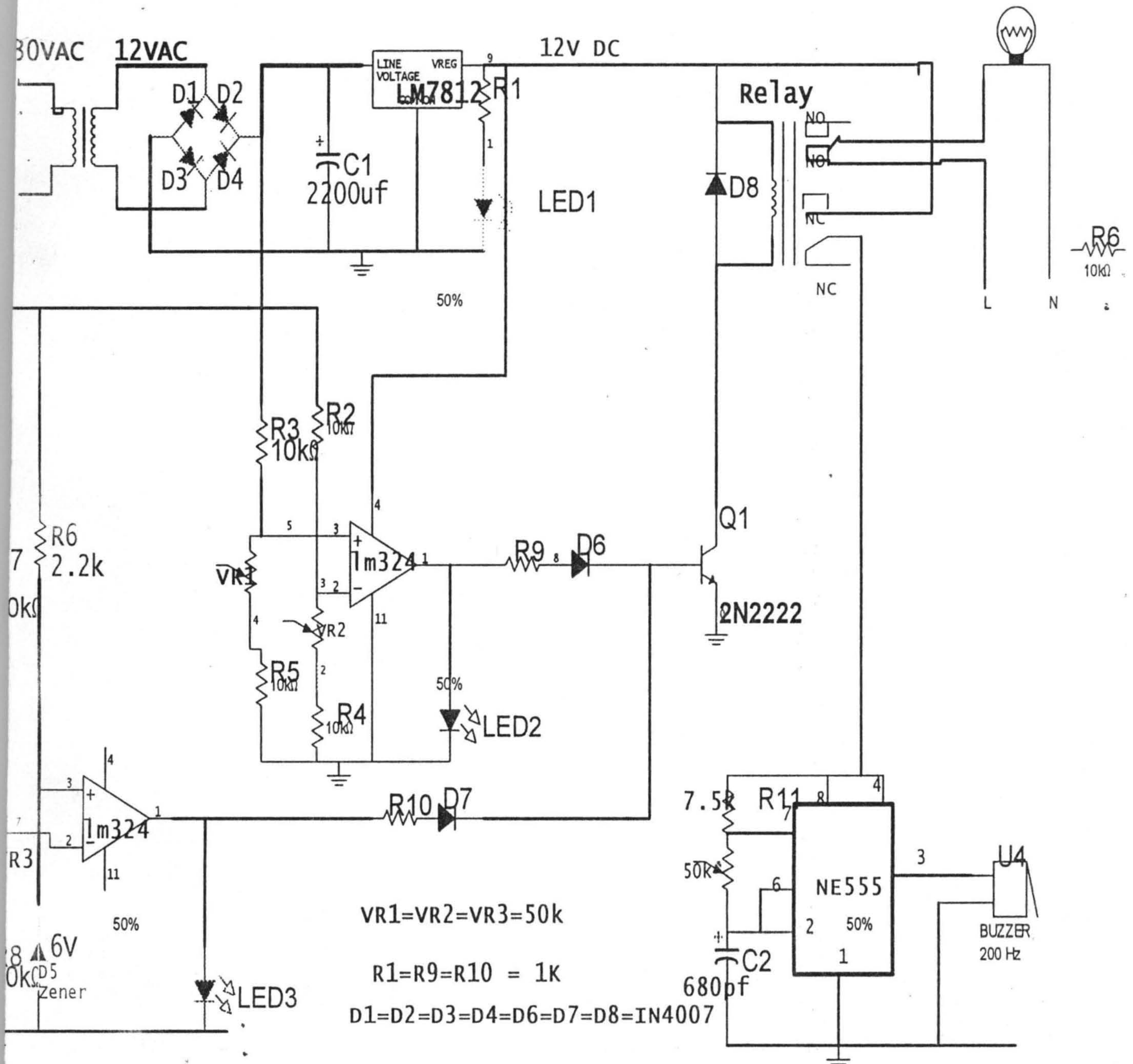


Fig 3.12 Switching network of alarm

3.6 Complete Circuit Diagram of power Fault Circuit Interrupter



CHAPTER FOUR

TEST, RESULT AND DISCUSSION

4.1 Test

This test aims at determining the voltage condition (levels) at which the circuit will cut off power supply to appliance in event of abnormality and also to that the entire circuit is working as designed.

The power supply, the comparator unit, switching stages and alarm were simulated on computer with a circuit simulator (multism) and then tested separately on bread board and each stage worked satisfactory. The whole circuit was simulated together and also tested on the bread board and confirmed to be working as desired.

Each stage was then transferred to the Vero board and confirmed to be functioning as designed.

4.1.1 Procedure

The apparatus for performing the test are 240\120 step-down transformer, a dimmer switch to be used for adjusting the voltage level, insulated flat nose screw drivers, and a voltmeter,. Due to the difficulty in securing an auto transformer to set the variable resistors for both the threshold voltage and maximum voltage operation. A little tactics was exploited by using adjustable DC voltage adaptor that gives variable DC out for testing the operation of the project.

It was observed that AC input voltage varies linearly to the DC output that goes to the comparator which acts as the main voltage sensor that activates the transistor for any change in the voltage. From the test, it shows that at voltage levels from (120-180), the relay switch is actuated, the normally closed contacts of the relay remain open due to the low voltage and red green LED remains ON indicating that there is power supply to the circuit and consequently the yellow LED. From 240V and above red LED remains ON indicating over voltage conditions

In real life, the value of variable resistance is present for determination of variation of voltage level across a premise wiring by switching "ON" and "off" of an auto transformer , by varying the value of the resistance, the voltage supply to the resistor changes and the circuit interprets this as a drop or rise in voltage along the wire or supply to the load: hence it operates the normally open relay contents, and either maintains your switches off power to the appliance it is being protected.

4.2 Project limitations

- Setting the variable resistor to the reference or determining threshold voltage for Various fault conditions because fluctuation of AC affects the pre –determined Values
- Getting all the modules to talk to each other was a great challenge

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Summarily, the Power fault circuit interrupter designed here detects fault conditions and disconnects power supply to the load but cannot correct them. It assists in troubleshooting the fault type using LEDs of different colors on the front panel of the circuit prototype. The response of the voltage switch to the simulated voltage condition is classified into the following conditions

i Under voltage due to high resistance (0-180)V

ii Normal voltage condition (180-240)V

iii Over voltage condition (240V and above)

The result from testing of the project shows that the device will compete well with other device and the following success were achieved.

(i) Detection of voltage fluctuations at abnormal condition with small resolution

(ii) Disconnection of power supply to protect appliances if senses abnormal voltage

(iii) Alerting the users by sounding alarm during fault conditions

(iv) It is cheap and will be affordable by domestic users and small business owners.

5.2 Recommendation

To implement multiple load modules to interface with one source.

REFERENCE

[1] www.electronics-lab/projects.html.monday, March 4, 2008

[2] Microsoft student 2008 [DVD]: “circuit breaker”, Redmond, Wa Microsoft Corporation, 2006.

[3] Microsoft Encarta 2007

[4] V.K.M EHTA and ROHIT MEHTA, Principles of power system, 2005, S Chand

[5] Charles a. Schuler, ‘Electronics principles and application”, 5 edition, McGraw-hill, Glencoe, New York, p14, pp202-203

[6] www.uic-edu/projects Monday, march 3rd, 2008.

[7] GROSS CHARLES, Faulty analysis in power system, CRC Press, Boca Raton 1993

[8] MEELDIJK VICTOR, Electronics servicing and Technology.

[9] ABB power system: “series capacitors for competitive power transmission.

[10] www.national.com, NTE data book’, 12th edition,2004.(general datasheets for all Component

[11] http://en.wikipedia.org\ comparator, Friday,5 July, 2008

[12] www.fairchildsei.com\lm339.pdf, Friday, 5 July, 2008.

[13] I Davis, “Awg cable description”, [online document],14 July, 2008, available, www.interfacebus.com\copper_wire_awg_size.html.

[14] Mor electric heating assos.inc,”electrical power wire”, [online document], 14 July, 2008, available, www.infraredheaters.com\wires.html.

[15] www.allaboutcircuit.com \vol_3\chpt-3\4.html (online document), 14 July, 2008

[16] John Gardner, talk on electrical fire for afi workshops on April IST, 2004.

[17] www.2d2c.com\pfci.php. July 31ist, 2008

[18] www.history of circuit breaker .com

[19] Paul Hurwitz, Winfield hill, “the art of electronics”-2nd edition, Cambridge University press, pp 641-652

[20] B .l and A .k the raja, "a text book of electrical technology, 2001, S Chand

[21] Zubair S,"Industrial electronics design {ECE 529} course material.

APPENDIX I

Operational manual

1 Install the device to the load you want to control.

2 Connect power cable to mains supply.

3 Switch on the power switch