DESIGN AND CONSTRUCTION OF A MULTI-SOCKET APPLIANCE FOR OVER VOLTAGE AND CURRENT PROTECTION

BY

ABUBABKAR ADAMS

2004/18766EE

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIRMENT FOR THE AWARD OF BACHELOR OF TECHNOLOGY (B.ENG) DEGREE IN THE DEPARTMENT OF ELECTICAL AND COMPUTER ENGINEERING.

SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY (SEET)

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA.

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DECLARATION

I Abubakar Adams declare that this work was done by me and has never been presented elsewhere for the award of a degree. I also hereby relinquish the copyright to the Federal University of Technology, Minna.

18/12/09

Abubakar Adams **Date**

CERTIFICATION

The project title design and construction of a multi-socket appliance for over voltage and current protection carried out by Abubakar Adams, Registration No.2004/18766EE, meets the standard deemed acceptable by the department of Electrical and Computer Engineering. Federal University of Technology, Minna.

18/12/09

Mr. Paul O. Abraham-Attah
Project supervisor

Date

May 6, 2010

Dr. Y.A. Adediran
Head of Department

Date

External Supervisor

Date 3/03/10

DEDICATION

This project is dedicated to Almighty Allah who has been wonderful to me. I also dedicate this project to my parents who has been my source of finance and Inspiration.

ACKNOLEDGEMENT

I acknowledge the presence of Almighty Allah in my entire life which has guided me all the ways.

I wish to express my profound gratitude to my supervisor, Mr. Paul O. Abraham-Attah for his support and concern. I sincerely appreciate your patience, advice and general counseling. It really ensured the success of my work. My Head of department Dr. Y. A. Adediran, Level Adviser Mallam Saddiq Abubakar, course lecturer on protective devices Dr Tsado Jacob and the entire staff of electrical department. Thank you all.

I also acknowledge the love, concern, care and support of my dear mother, father, Uncle Aliu Garba, brothers and my one and only sister Queen Amina for their financial support and prayers toward my success. May Allah bless you all. (Amen)

The same acknowledgement goes to Uncle Kevin I. Udeh who died as a result of his good works which enemies never liked. He stood by us as a family, guided our success to see the light of the day. Sir, you will always be remembered. May your gentle soul rest in perfect peace!

I must not forget my friends, colleagues and well wishers for their moral support, may God bless you all. I love you.

ABSTRACT

The multi-socket appliance for over voltage and current protection was designed and constructed to provide a suitable protection system to an electrical appliance, which could draw power safely from either mains or generator without damage. The circuit was tested and found working perfectly as designed.

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CHAPTER ONE

1.1 GENERAL INTRODUCTION

The idea of this project emanated from the incessant damage of an electrical appliance due to an abnormal voltage or current supplied by the power holding company of Nigeria (PHCN). The recent one was my laptop charger which got burnt by a generator. Based on this experience, I decided to come up with a protective device that would be effective and affordable to the end user as a young entrepreneur.

The history of electrical-power technology through out the world is steady and in recent years, rapid progress is made. This has made it possible to design and construct economic and reliable protective device capable of satisfying the continuity growth in the demand for electrical energy within the household.

Power system protection and control play a significant part of these effects, progress in design and development in these fields necessarily had to keep pace with advances in the design of primary plant, such a generators, transformers, switch gears, over head lines and underground cables. Indeed progress in the fields of protection and control is a vital pre-requisite foe the efficient operation and continuing development supply as a system as a whole.

No actor wants to be temporarily removed from the system due to incorrect protection behaviors as this may lead to an (unnecessary) absence of income, penalty/ transmission and distribution of electrical energy system is a costly business. At different stages of energy processing i.e. generation transmission, distribution and utilization (figure) protection of personal and equipment if of prime importance.

It should be noted however, that the term protection does not indicate or imply that the protection equipment can prevent faults or failures of equipment. It can not anticipate faults either. The protective relays acts only after an abnormal or intolerable condition as occurred with sufficient indication to permit their operation, thus protection does not mean prevention but rather minimizing the duration of the trouble and limiting the damage and indeed isolating faulty section and equipment of a power system.

Figure 1.0 shows a decision flow chart that explains operation of a general protection processes that might be implemented in a computer control system. Usually, the system is in the normal state and the protective device is said to assume that the normal state prevails and startup. As time is incremented, the protective device checks and observe system variables, represented by V & I in the flow chart, to determine if any variable exceeds the threshold value if not, time of 10 seconds is incremented to observe the next measured value. If the threshold V_{in} exceeded, the time threshold is checked and tripping action is withheld until the time threshold expires. When both the voltage and the current threshold are exceeded, the circuit is tripped.

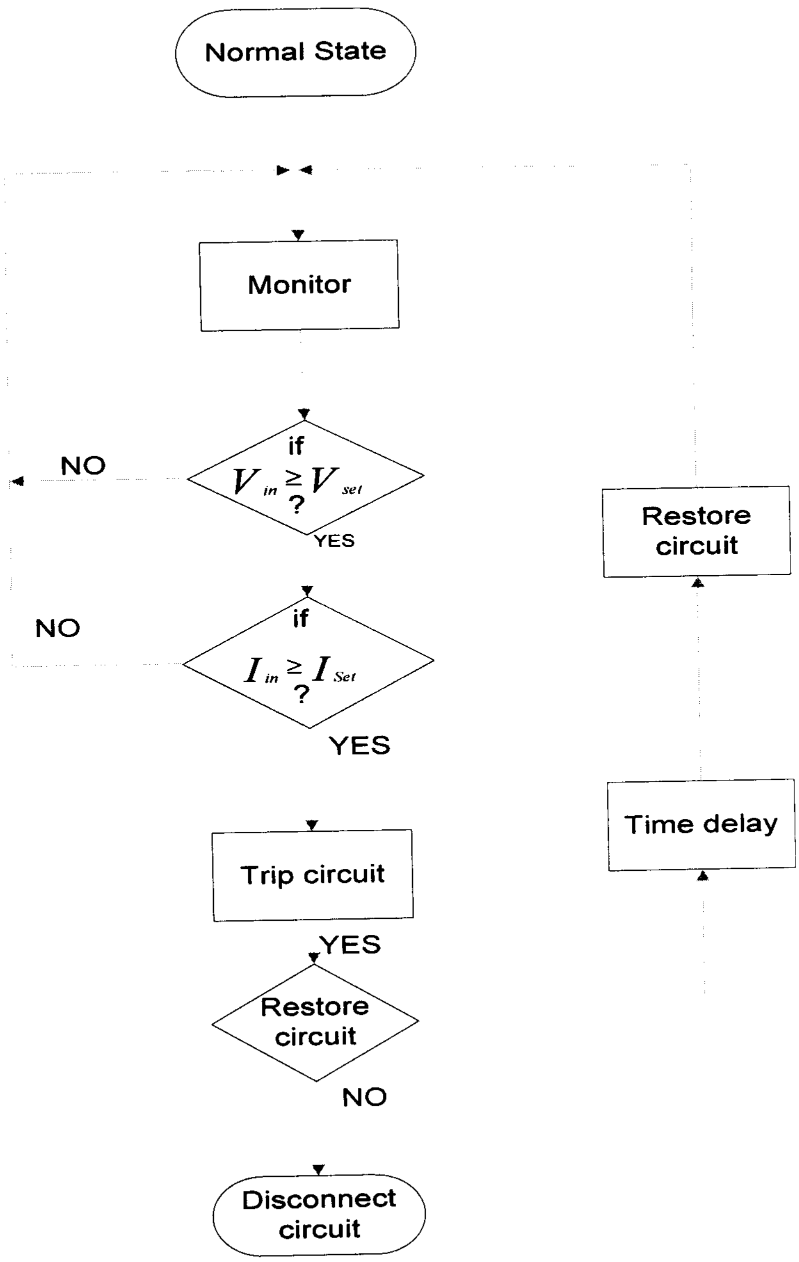

Fig 1.0 Flow Chart of Protective Device Functional Diagram

Where;

V_{in} is the input voltage

V_{set} is the preset voltage

I_{in} is the input current

I_{set} is the preset current

This type of logic is designed to provide tripping for short, temporary disturbances that might be observed. Such disturbances are often a part of the normal operating condition of the network, and tripping should not be initiated for such events. In some protective systems, automatic restoration is begun following a present time delay, this concept has proved valuable since most power system disturbances are temporary.

Ideally the supply of electricity is constant without any interruptions but this has been difficult to achieve due to the following situations which arise during power generation, transmission and distribution.

1.1.1 INTERRUPTION OF POWER

Interruption of power maybe due to the transient fault on any part of the power system, because, whenever a circuit goes from one form to steady-state condition to another steady-state condition, it passes through a transient state which is of short duration [1].

This could also be caused by lightening strikes, breakdown in an insulation system, overloading on the equipments etc. And as a result it can cause short-circuit on the transmission lines.

When this situation occur, the protecting device is energized thereby cutting off supply of power to the affected area and may immediately restore power once the object is removed and fault rectified. This situation is undesirable because it can damage equipment such as Air conditioning, Refrigerator and Electronics gadgets. The effect of interruption, fluctuation or overvoltage and over current could be a deserter on any appliances.

1.1.2 OVER VOLTAGE AND OVER CURRENT

The overvoltage and over current condition occur when the voltage or current exceed normal steady state limits. Thus, an abnormal voltage or current occur when there is an insulation breakdown in any part of the system that supply the power [1].

The effect of over voltage is hazardous to life and equipment. Overvoltage will cause over excitation (Increase in torque) in electric motor which may result in possible damage to all the coupling of the appliance.

Other loads as water-heater, electric cooker and toaster. Over voltage will cause heating elements to burn out quickly and the expected durability of electronic components will decrease. Some components will get destroyed immediately once voltage above the rated value is applied e.g. filaments of illumination loads (bulbs, incandescent lamps and fluorescents) get damage quickly when there is over voltage. These situations are not desirably in power system because electrical devices are designed to operate at a specific voltage with some tolerance outside of which electrical performance is degraded and breakdown may occur [2,3].

1.2 AIMS AND OBJECTIVES

In electronics quality service requires maintenance at power voltage without interruption or fluctuation. Although, distribution lines are designed to maintain the voltage of customers premises within acceptable limits.

The protection of device is to accomplish by a circuit whose contents are a timer, a relay, a transformer, current sense resistor and an operational amplifier.

The main objectives of the circuit are:

- Provides a constant voltage source for appliance.
- Ameliorate the incessant and excessive damage in an electronics circuit.
- Alerting the user of the abnormal voltage and current conditions.
- Provides fast protection against high voltage and that could cause damage to sensitive components.
- To achieve a low cost of protective device.

1.3 METHODOLOGY

The construction of over-voltage and over-current protective circuit for electrical appliances require an over-voltage and over-current comparator I.C LM358, transistors, resistors of various values, variable resistor, current sense resistor and relays.

1.4 SCOPE OF PROJECT

The concept and motivation of this project is to design and construct a multi socket circuit with over voltage and current protection to our electronic equipment because of the voltage fluctuation usually outside the standard range. This project objective is to reveal that the multi socket circuit is economically and affordable.

1.5 SIGNIFICANCE

The main importance of the project is:

- To provide a constant voltage source for appliance
- To avoid surge due to fast change in voltage
- Control the maximum amount of flowing into appliance
- Protect appliance from excess current
- To provide a minimum time delay for current flow in our appliance to avoid current surge.

1.6 JUSTIFICATION

Since the multi socket circuit with over current and over voltage protection, protect the terminal voltage without the use of external agent. It is a short cut power supply to electronic device and protects them against damage. It is used for sensitive industrial and domestic equipment e.g. computer, refrigerator, TV set, radios etc.

1.7 SOURCE OF INFORMATION

The material used on this project was sourced from textbooks, internet, final year projects and lecture notes. Furthermore, I however consulted my lecturers' right from the design to construction.

CHAPTER TWO

LITERATURE REVIEW/THEORETICAL BACKGROUND

2.1 INTRODUCTION

After the invention of electricity, over voltage and over current were the first sets of problems encountered in its utilization. For electronics component to perform effectively, it however need constant power supply.

2.2 HISTORICAL BACKGROUND

Electrical power anomalies or disturbances can disrupt the normal operation of equipment, accelerate ageing, or even course outright failures thus resulting increased cost of maintenance and reduced system reliability as stated by Liu, s et al [4]. Ollero, Charles A. H. [5], in his paper presented at telecommunication energy conference, 1996 INTELEC "96 18th international designed a multi- output power converters combat low voltage supplies to microelectronics. This paper presented two techniques (one to post-regulate the non – regulated out put in multi-output converters and the other to achieve an easy and cheap over or under voltage protection) taking advantage of rectifier MOSFETs used for synchronous rectification.

2.3 LITERATURE REVIEW

A voltage sensitive device called over voltage –under voltage sensor was invented by Steven et al[6].The device controls the energization of a relay or other load so as to switch it between energized and de-energized state as the said sensed voltage passes a low or under voltage limit and another high or over voltage limit. Detection of high and low limit is achieved by voltage detecting circuits, performs the actual switching of the load between its energized and de-energized states. The two detecting circuits and the comparator are each comprised principally of a programmable injunctions transistor or other three-terminal semi-conductor device of generally similar characteristics.

Also, another inventor Monera A. S. [7] introduced an under voltage protection circuit. The device is prodded for sending a reset signal to an electronics device during under voltage periods in which the device during under voltage periods in which the device power voltage is less than a desired amount. The protection circuit includes a sensing circuit and latching network adapted to quickly discharge a storage capacitor when the sensing circuit senses the under voltages. A buffer network is included to send a reset signal to the electric device when never the storage capacitor discharges to a low latched level. The reset signal exist substantially throughout the under voltage time ceases. During the received of reset signal, the electronic device will be inhibited from damage or loss of data.

Some power utility companies in the united State of American (USA) are not left out in finding solution to power fluctuation problems. Such company is Texas instruments [8] which introduces under voltage protection equipments brand named as TPS2400.The TPS2400 controller is used with an external N-channel MOSFET to isolate sensitive electronics from destructive voltages spikes and surges. It is specifically designed to prevent large voltage transients associated with automotive environments (loads dump) from damaging sensitive circuitry, when potentially damaging voltage levels are detected by the TPS2400, the supply is disconnected from the load before damage can occur.

Internal circuitry of TPS24000 includes a trimmed band-gap reference, oscillator, zener diode, charge pump, comparator and control logic. The TPS2400 is designed for use with an external N-channel MOSFET which are readily available in a wide variety of voltages. The disadvantage of this device is that it is costly.

Another company named MAXIM [9] also invented an over voltage and under voltage, protection switch controller brand named MAX6399. The MAX6399 is a small over voltage and under voltage, protection circuit. The device can monitor a DC-DC output and quickly disconnect the power source from DC-DC input load when an over voltage condition occur. This has controller architecture which provides the ability to size the external N-channel MOSFET to meet specific load current requirement.

When the DC-DC monitor output voltage is below the users –adjustment over voltage threshold, the GATE output of the MAX6399 goes high to enhance the N-channel MOSFET. When monitored output voltage rises above the adjustable over voltage threshold, the GATE output rapidly pulls low to shut off the MOSFET. The MOSFET remains latched off until either the MAX6399 Input power or SHDN-bar inputs is cycled.

Another approach is the use of circuit breaker s. A circuit breaker is an electrical device that cuts off the electric circuits through a circuit under abnormal conditions.

Hodkinson G. L. [10]. The most familiar household circuits' breakers protect circuits against over loading or over heating to prevent fire.

Circuit breakers also provide protection against short circuits. Common household circuit breaker is made up of coil of circuit called a solenoid and an iron plunger inserted partially inside the solenoid. When circuit flow through the solenoid, it produces a magnetic field just as low magnet would. The strength of solenoids magnetic field depends on the amount of circuits flowing through it. When 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 circuit breakers is that they do not offer effective fast switching protection of electronic appliances as they on offer protection in the event of short circuit and not over/under voltage condition [8. 11].

The under voltage and over voltage protection circuit presented in this project is a low cost and reliable circuit for protecting domestic appliances refrigerators, computers, televisions etc. from the posed by voltage or over voltage fluctuations. It uses potentiometers to set the reference voltages for over/under voltage condition, switches the transistors on /off and energized /de energizes the electrochemical relay in accordance with the voltage condition.

Normally, the value of variable resistance is preset for the under voltage or over voltage switching ON and switching OFF actions of the transistors (with the use of autotransformer) but by varying the value of the resistance. The voltage supply to the transistor changes and the circuit interprets this as drop or rise in supply voltage switch (transistors) rheostat resistance is reduce to stimulate the under voltage condition and the value of under voltage rheostat has been restored (to its original approximate value) to stimulate the voltage conditions.

Whenever the circuits is switch-on and the electrical appliances is connected to it, is supply and maintains a steady DC to the electrical appliances during normal conditions and cut off power supply during abnormal conditions it senses an out put voltage representing the voltage input of supply, generates a reference voltage, compare the input voltage with the reference voltage detects whether there is an over/under-voltage condition that is when the reference voltage exceeds or is less than the input voltage, and disables the power supply from the appliance when the over/under-voltage condition is detected.

The circuit is not expensive and not bulky, it's easy to construct, has high switching speed.

CHAPTER THREE

DESIGN AND CONSTRUCTION

3.1 DESIGN AND ANALYSIS OF THE PROJECT

This chapter deals with the design, methods and the analysis employed in the design of an over current and over voltage protective circuit.

3.2 BLOCK DIAGRAM

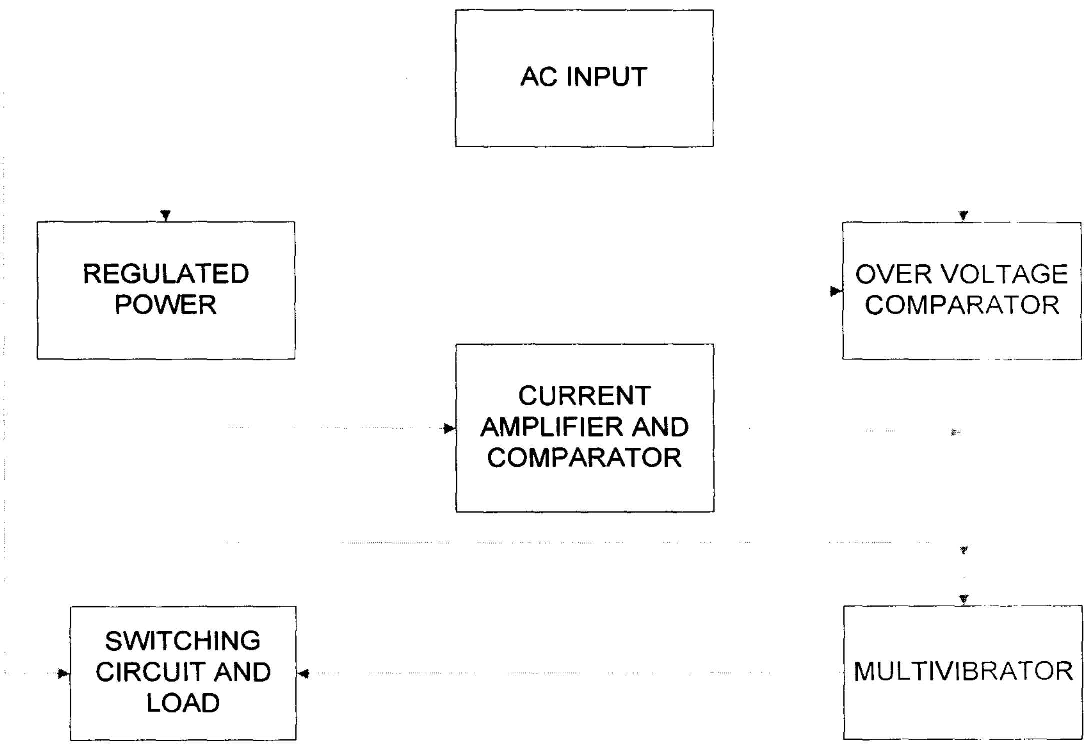

Fig 3.0 Block diagram of a multi-socket for over voltage and current protection.

3.3 IMPLEMENTATION

The overvoltage and over-current detector was re-solved around the following sub-systems:

- system power supply
- current sensor and amplifier
- over-voltage sensor and comparator
- 555 timeout monostable
- Relay switch and its loads
- On/Off control of the circuit

3.3.1 SYSTEM POWER SUPPLY

A half-wave rectified DC supply was implemented in the system's design. The power supply type was utilized due to the requirement of a continuous ground return between the AC powered load and the detector system. The power supply is as shown in fig. 3.1

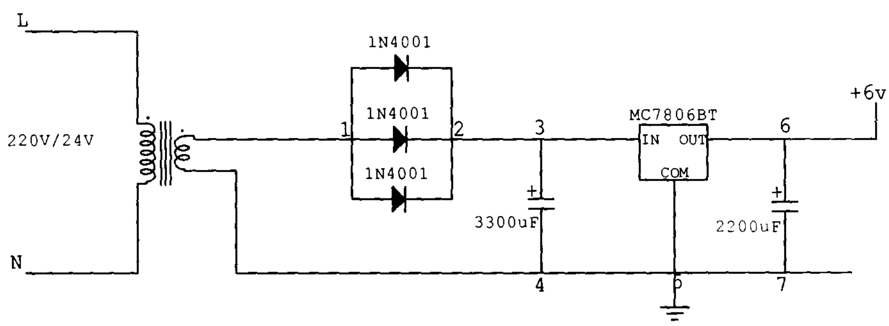

Fig. 3.1 System Power Supply.

A low-voltage 24V AC was derived from 220V/24V step down transformer. The AC voltage was converted to a 50Hz pulsating DC voltage by a rectifier designed around D1-D3.

Parallel connected diodes were used to reduce the resistance of the diodes and thus, provide higher current than would be possible if only one diode was used.

The DC voltage was smoothened by a 3300μF capacitance.

$V_{dc} = \frac{1}{\sqrt{2}} (V_{rms})$ 3.1

$V_{dc} = 0.707\ (24)\ V$

$V_{dc} = 16.8V$

The value of smoothening capacitance was evaluated from the expression; [6]

$C = \frac{it}{\Delta v}$ 3.2

Where; V_{dc} is the dc voltage, V_{rms} is the root means square voltage, i = maximum load current, t = time, C = capacitor.

$t = \frac{1}{F} seconds$ 3.3

where ; F = power frequency, t is the time.

ΔV = peak-peak AC ripple voltage. 3.4

Where; ΔV = differential voltage.

ΔV was determined by the minimum input voltage into the 7806 regulator. For a regulated 6-volt output, the minimum input voltage is 8V.

On a 16.8VDC input, the peak-peak ripple voltage is (16.8-8) = 8.8V.

The maximum Load current was pegged at the maximum allowance by the transformer, i.e. 0.5A.

Calculating for Capacitor:

$$C= \frac{0.5\times\frac{1}{50}}{8.8} = \frac{0.5\times 0.02}{8.8} = 0.00113636 \equiv 1136\mu F$$

The rate was increased to 3300μF to improve the system's performance of smoothening the dc voltage. The smoothened DC voltage was regulated down to +6V by a regulator (7806) d

Device as shown in fig 3.0, thus, a capacitor of $2200\mu F$ was connected across it for stability.

3.3.2 CURRENT SENSOR AND AMPLIFICATION.

A resistive current-to-voltage converter was used to sense and convert the load current to voltage. An 0.1Ω resistance was inserted in series with the load as in fig 3.2

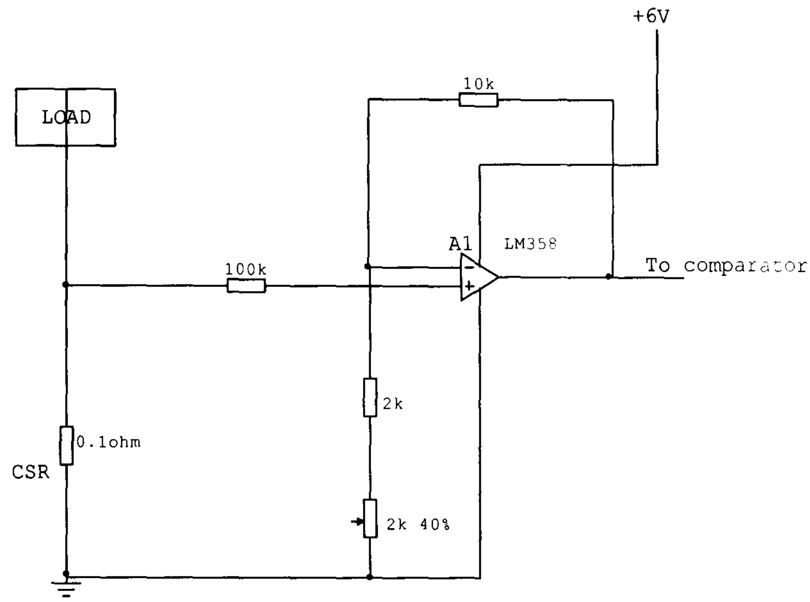

Fig. 3.2 Current – Voltage Converter and Amplifier.

The current through the load resistance is converted to voltage. The AC voltage is amplified by a DC-coupled amplifier with a gain adjustable from 3.5 to 6. The amplified output is fed into a comparator where it is compared with the preset current level, the comparator switches its output high, an trigger a 10-seconds time out monostable via an NPN transistor.

The comparator is diagrammed below:

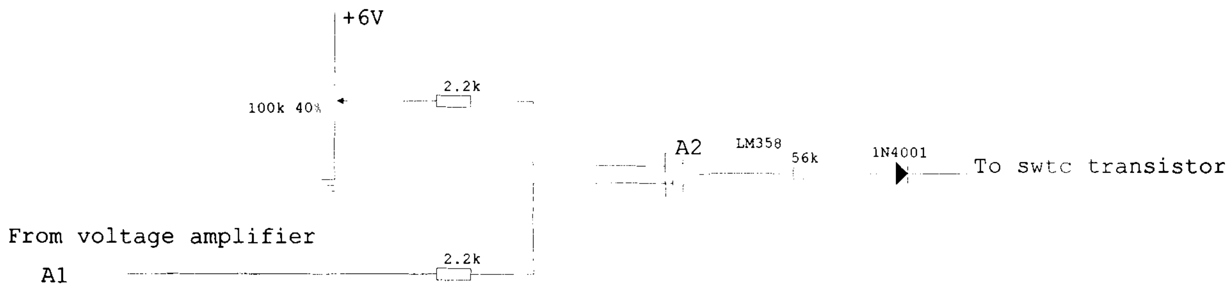

Fig. 3.3 Operational Amplifier and Comparator

A comparator is a circuit that compares the magnitudes of the voltages at its input, non-inverting and inverting, and switches its output high or low to reflect the greater of the two voltages.

AULM358 operational amplifier was used as the comparator. The non-inverting input was fed by the amplifier AI output. Its inverting input was converted to a potential divider fed by the +6V system supply. The potentiometer is freely adjustable, hence different current level settings can be made [2].

3.3.3 OVER-VOLTAGE DETECTOR

For over-voltage inverting, a second comparator was utilized. The inverting input of the comparator was converted to a fixed potentiometer. Its non-inverting input was fed with a stepped down AC voltage from the 240V mains as shown in fig. 3.4

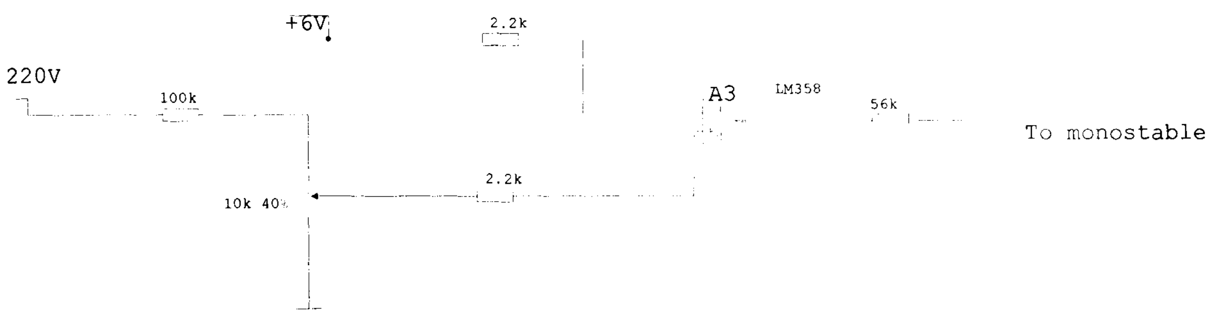

Fig. 3.4 Over-Voltage Detector and Comparator

When the instantaneous voltage on the non-inverting input exceeds the voltage level on the inverting input, A3's output switches high momentarily, triggering the driver transistor wired to pin 2 of the monostable.

3.3.4 TIMEOUT MONOSTABLE

To detect the load on detection of over current or overvoltage, a monostable was provided. The monostable provides about 10-seconds disconnect for the loads. The monostable was triggered by the outputs of comparator A2 and A3 via a common emitter transistor switch.

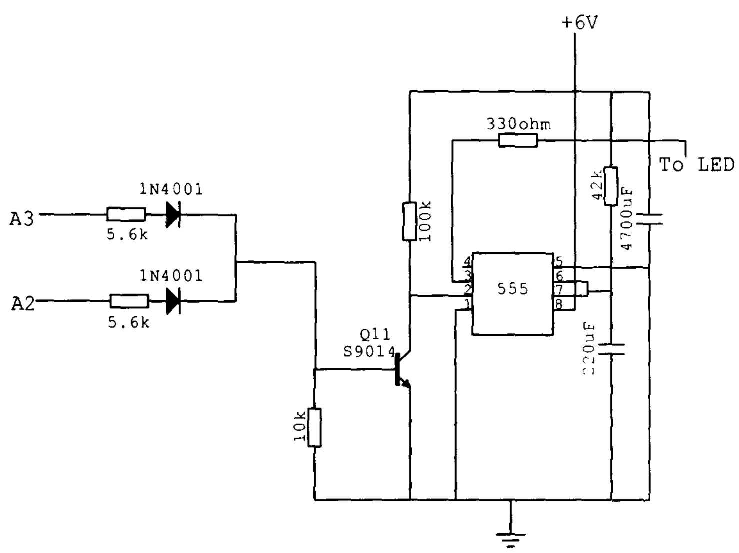

Fig. 3.5 10-Seconds Monostable Timeout Generator

The 555 monostable produces an output that is at logic 1 (high) for a period of time determined by the rate of the RC timing components on pins 6 and 7. the output can be returned to low by pulling pin 4, reset to ground, or waiting for the device to time out. Since the outputs of the two comparators are high when the over current and overvoltage consider are detected and the 555 requires a high to low transition on pin 2, an inversion of the comparators' output was required [9]. A C914 transistor effected this.

A 10-second timeout was designed for, the values of the PC components were chosen as 42kΩ and 220μF.

$T = 1.1\ R_T C_T$ 3.5

Where; R_T is the timing resistor and C_T is the timing capacitor

$T = 1.1 \times 42 \times 10^3 \times 220 \times 10^{-6}$

$= 10$ seconds.

3.3.5 RELAY SWITCH

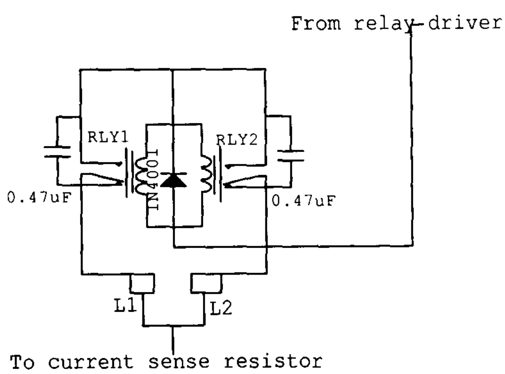

Fig 3.6 Relay Switches and Its Loads

Whenever the monostable switches high, the base current of the relay driver transistor is always shunted to ground, forcing the relay off.

The Loads' status was user – controlled by a second 555 connected as a set-reset flip flop. Two buttons to ground were connected to pins 2 and 4 pulled up to V_{cc}. The normally closed which is connected to the appliances is turned off when the circuit sense a low or high voltage. The circuit was tested and found working perfectly as design specification.

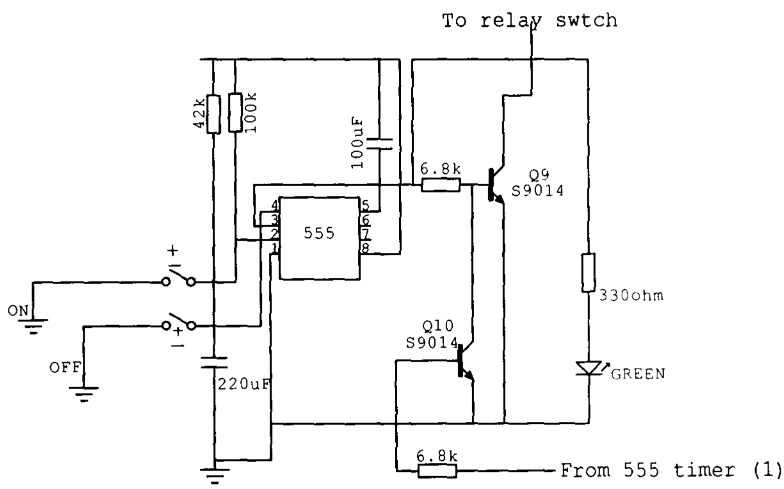

Fig. 3.7 On/Off Control of the circuit

At power-up, the two 555 chip are held in the reset state, and the two AC outputs are disconnected from the mains.

The system can be started by pressing the 'ON' button. Closing the 'ON' button sets 555(2), forward-biasing Q1 in fig. 1.4 and energize the relay. The two outputs are connected to AC at this point. Closing the 'OFF' key resets 555(2), turning off Q2 and disconnecting the loads.

Automatic overrides of the ON/OFF control are done via Q2 driven by the monostable. Whenever Q2 is high, i.e. whenever an over voltage and over current condition is detected, Q2 shuts the pulse driver of Q1 to ground, forcing the relays off.

Two relays were placed in the collector circuit Q1. The two relays have a coil resistance of 420Ω each, at a coil voltage rating of 6V.

Where; Q1 is the transistor (1) and Q2 is the transistor (2).

$$I_{relay} = \frac{6}{420} = 14.3mA \qquad \ldots\ldots 3.6$$

$$I_{relay}(total) = 2 \times 14.3mA = 29mA$$

The DC gain of Q1 is about 200

$$I_b = \frac{I_c}{H_T} = \frac{0.029}{200} = 0.145mA \qquad \ldots\ldots 3.7$$

$$R_B = \frac{V_b - V_{be}}{I_b} \qquad \ldots\ldots 3.8$$

$$R_B = \frac{V_{out(555)} - V_{be}}{I_b} \qquad \ldots\ldots 3.9$$

$$R_B = \frac{4.5 - 0.7}{0.145 \times 10^{-3}} = \frac{3.8}{0.145 \times 10^{-3}} = 26.2k\Omega$$

Where; I_{relay} is the relay current, I_b is the base current, I_c is the collector current, H_T is the gain of transistor (Q1), R_B is the base resistor, V_b is the base voltage, V_{be} is the base-emitter voltage,

A 6.8k Ω value was used instead to assure switching under all possible conditions. Thus, all values of diodes are in1N4001 each, except otherwise stated.

CHAPTER FOUR

TESTS, RESULTS AND DISCUSSION

4.1 TESTS

The system multi-socket appliance for over voltage and current protector was tested by connecting the input to the main supply and the output was tested with multi-meters, variac device and further tested by a pressing iron of 1000 watt rating which worked perfectly. The institute of electrical engineering regulation for electrical equipment of building stipulates that for safe utilization of electrical energy, the fluctuation of normal supply at anytime must not exceed $\pm$ 6%. In Nigeria, the normal domestic supply phase voltage is range between 225.6 to 254.4V. From this regulation, voltage/current protector is safe to be applied in sensitive domestic electronic components.

4.2 RESULT TABULATION

	PRIMARY VOLTAGE(V)	SECONDARY VOLTAGE(V)
Low voltage	110	7.7
Normal voltage	240	16.8
High voltage	250	17.5

4.3 DISCUSSION OF RESULT

4.3.1 LOW VOLTAGE CONDITION (110V)

From the test it was observed that even at low voltage level the system worked but, must not be less than 110 volts, to avoid the relay switch de-energized.

4.3.2 NORMAL VOLTAGE CONDITION (190-240V)

When the supply voltage from the mains was at this range (190-240V), it was observed that the relay was operating normally. The normally open contacts of the relay closed for the flow of current in the circuit. The two picks up current and begin to function.

4.3.3 OVER VOLTAGE CONDITION (250 AND ABOVE)

The general purpose of the project is to avoid over voltage when the supply volt was at 250 volts and above, the relay became de-energized as was observed. The normally open contact of the two relays remain open, the socket output switch off automatically and remain in an off condition until the normal voltage comes up. The users reset and switch it on.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 SUMMARY

The project was designed and constructed in such a way that any input voltage that exceeds the normal voltage of 240V or falls below 110V. The device is sets to disconnect to protect the circuit.

Assessment of the work has shown that it can serve the purpose of domestic electronic appliance that uses power of not more than 2000Watts.

5.2 CONCLUSION

Therefore, design and construction of over voltage and over current protection was successfully carried out. The result from the testing of the project show that the device will compete well with other protective devices in its class. It's capable of protecting electrical and electronics appliances for example television set, radio set and other household gadgets from damage due to voltage fluctuation.

5.3 RECOMMENDATION

The device is suitable for electrical and electronic appliances with input rating of not more than 240V, therefore, for efficient operation; the appliance to be protected by this project should fall below this range.

- This project can be improved upon, as higher voltages can also be regulated for industrial appliances.
- Alarm unit can be incorporated to sound a warning if the operating condition falls below or rises above the desired operation voltage range.

REFERENCES

1. B.L Theraja and A.K. Theraja: Textbook on Electrical Technology, S. Chand and Company Limited, Schandgroup.com, Shand@vsnl.com, ISBN: 81-219-2441-3. Pp 245, 1605.

2. Charles A. Schuler: Electronics Principles and Applications, Glencoe/McGraw-Hill, 8787 Orion Place Columbus, ISBN: 0-02804244-1. Pp 165, 169, 267.

3. Tom Duncan: Success in Electronics. 2nd edition, John Murray Publisher Limited, London (1996), ISBN: 0-04-665748-9. Pp 113,147.

4. www.chipwinner.com/Ds/LM358.pdf

5. Charles, A.H: Electronics Circuit, John Wiley and Sons, New York, ISBN: 0-471-0446, (1992). Pp 201, 204.

6. www.powerfactorine.com/9Power-Problems/undervoltage

7. Monera A.S: Solid State Electronics Circuits, For Engineering Technology McGraw-Hill Book Company (1973) New York, USA, ISBN: 0-07-041401-7. page (48, 49, 50).

8. J.F Whitefield: Electrical Craft Principles, Peter Peregrinus Limited, London UK, ISBN: 0863411541.(1930), Pp 112, 116.

9. Giorgio Rizzoni: Principle and Application of Electrical Engineering, Revised fourth edition, Hamilton Printing Company USA, ISBN: 0-471-62242-7. Page (129, 520).

10. William E. Long and Paul L Evans: The Technician Electronic Principles and Circuits, John Wiley and Sons Limited, USA, ISBN: 0-471-54455-8, (1979). Pp 94, 95.

11 Meadows R.G: Technician Electronics volume 2, Cassell Limited, 35 Red Lion Square, WC1R 4SG London, ISBN: 0304305383. page (115).

12 R. F. Coughlin & E. F. Driscoll: Operational Amplifiers and Linear Integrated Circuits, Prentice-Hall International Publisher, New Jersey (1987), ISBN: 0-12-550723-2, Pp 210, 317.

13 www.Maxim-IC.com/quick view2.cfm/qu pk/4753

14 Redmond, W. A: "Circuit Breaker" Microsoft[R] Student 2007 [DVD]

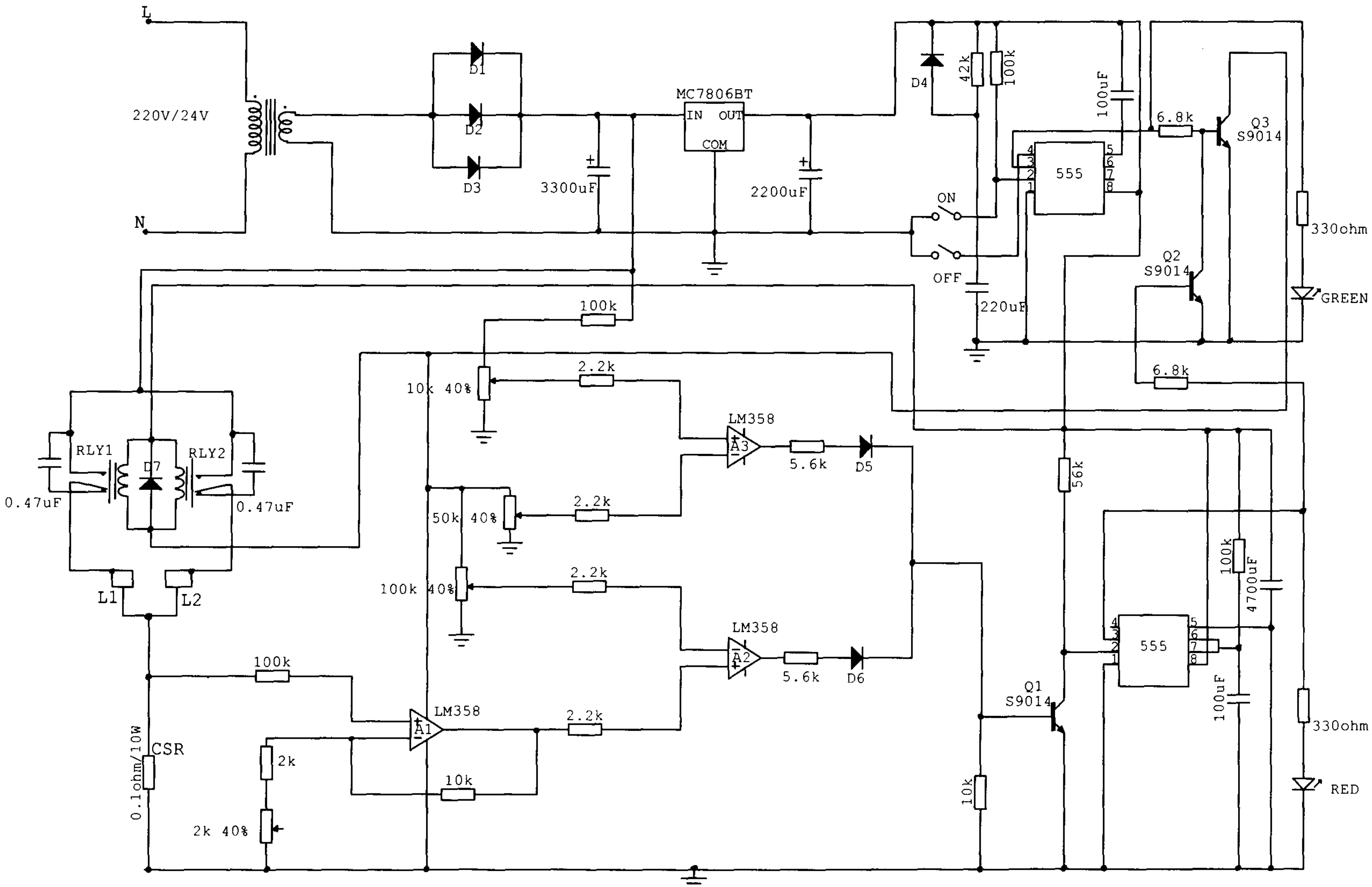

Fig 3.8 COMPLETE CIRCUIT DIAGRAM