DESIGN AND CONSTRUCTION OF AN OVER VOLTAGE AND OVER CURENT PROTECTOR

BY

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DEDICATION

I dedicate this project to ALLAH [SWT] and to my parents, Mall and Mallama Adamu Sabo kutigi who have seen to the fulfillment of my dreams in life.

DECLARATION

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

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ACKNOWLEDGEMENT

My thanks goes to Allah [SWT], for sparing my life till this moment and for his grace given to me to complete this work successfully.

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I am grateful to my Father Wokili Nufawa Kwali-Abuja . Mall Adamu Sabo Kutigi for his precedented support morally and financially throughout my dreams in life and to my beloved other Mallama Zainab Adamu who also champion this course but later answer the call of lah. My gratitude also to my step mum Nnagi Habu and siblings, ,Engr Madugu, Salamatu, haji Sabo and the rest, for their courage and support.

My piece would not be completed without mentioning and thanking my special friends o stood by me against all odds; Umar, Sani, Abdulkabir, Muslim, Ndagi, Moh'd, Jamiu and er numerous to mention. They remain permanent on the scrolls of my heart.

ABSTRACT

This project work is on the design and construction of over voltage /current protector, which is used to cut off the supply to electrical equipments due to excessively high voltages and current not within the limits of 190v to 240v from the supply and 10 of current. The main aim of this project is to provide a simple, cost effective and user-friendly electronic system that continuously monitors the AC line voltage and current. The project has two comparators which are used to sense voltage and current levels as present by the variable resistors built around the comparators. When the supply voltage to the voltage level monitor is higher than the upper trip point voltage preset by the variable resistor, the sensing circuit send appropriate signal to disconnect the load through the relay. when the current to the current level monitor is high than the trip point current, it sends the appropriate signal to disconnect the load through the relay. when the supply voltage and current is within the preset voltage/current, the monitors connects the load to supply. The voltage/current monitors functions as above to connect or disconnect equipment from supply in the event of overvoltage or over current

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Expository Introduction

This project, design and construction of a digital over voltage and over current protector, is an electrical and electronic devices , that protects electronic and electrical appliances during over voltage or over current condition by cutting off supply automatically and goes on standby mode.

1.2 Over voltage conditions

Over voltage could be as a result of either lightening or switching over voltages. Lightening over voltages as a result of a natural phenomenon while switching over voltage originates from connection and disconnection of circuit breaker contacts at switching. Over votage occurs when the voltage in circuit is raised above its upper limit or sustained voltage that exceeds normal steady state limits. this condition is hazardous to lelectronic and electrical appliances, as they are designed to operate at a certain maximum supply voltage ,and considerable damage can be caused by voltage that is higher than for which they ted[1]

1.3 Over current condition

Over current condition ma y occur in the form of overload or short-circuit resulted as a result of current in excess of the normal current for a give circuit. Overload are over current which are range between twice and ten times the normal current while short-circuits are relatively large over current which may exceed the normal current by hundreds of times and flow between the circuit and other objects outside the circuit. any over current is potentially destructive to equipment and dangerous. For example if a cable

carries current twice its rated current for a long time it is possible that damage will occur.[1] ES

1.4 PROJECT OBJECTIV

The main purpose of this project is to design and construct a protective devices that will protect against over voltage and over current for all equipments

The objectives of this project satisfies the following conditions

1. provide a constant voltage sum for appliances
2. to avoid surge due to fast change in voltage thereby also efficiently discriminate between normal and abnormal system.
3. Cut-off power to the equipment protected when there is over voltage and over current.
4. Control the maximum amount of current flowing into an appliance from excess current.
5. Provide a minimum time delay for current flow in our appliance to avoid current surge and restore power to the appliance protected as soon as power system is return to normal.

1.5 SIGNIFICANCE OF THE PROJECT

This device is used to protect equipment from over voltage and over current, and it found application in all electrical equipment which have been designed to operate at an input voltage/current within the range of 240/9V and 10A

The device ensures that the components in the equipment work under stabilize voltage and current thereby increasing their reliability within its useful life period. It

reduces cost of maintenance that can be required due to damages caused by power fluctuation.

1.6 SCOPE OF THE PROJECT

This protective device has been built especially for the protection of all equipments operating within the range of 240/9V and 10A.It cut-off the output supply to the load automatically whenever the input voltage/current outside this range.

1.7 PROJECT'S METHODOLOGY

The design and construction of this project comprises of step-down transformer, diodes, resistors, capacitors variable resistor,555 timer, digital op- amp, inductor current transformer, AND GATES, LEDS, transistors, and relays. Also induced in the construction are bread boards, vero board, soldering iron, soldering leads etc

This project employ two transistor in conjunction with diodes to energize mand denergize a relay during normal voltage/current and over voltage/over current conditions respectively. when this system is powered it goes on standby –mode until a pulse is sent using pulse switch to set it on. This system monitors an incoming voltage from the supply so that when it exceeds the required set value it switches the output off with the help of a relay, therefore going on its initial standby –mode unit required voltage is maintained. When the required voltage and the power supply is restored the system remains on standby-mode

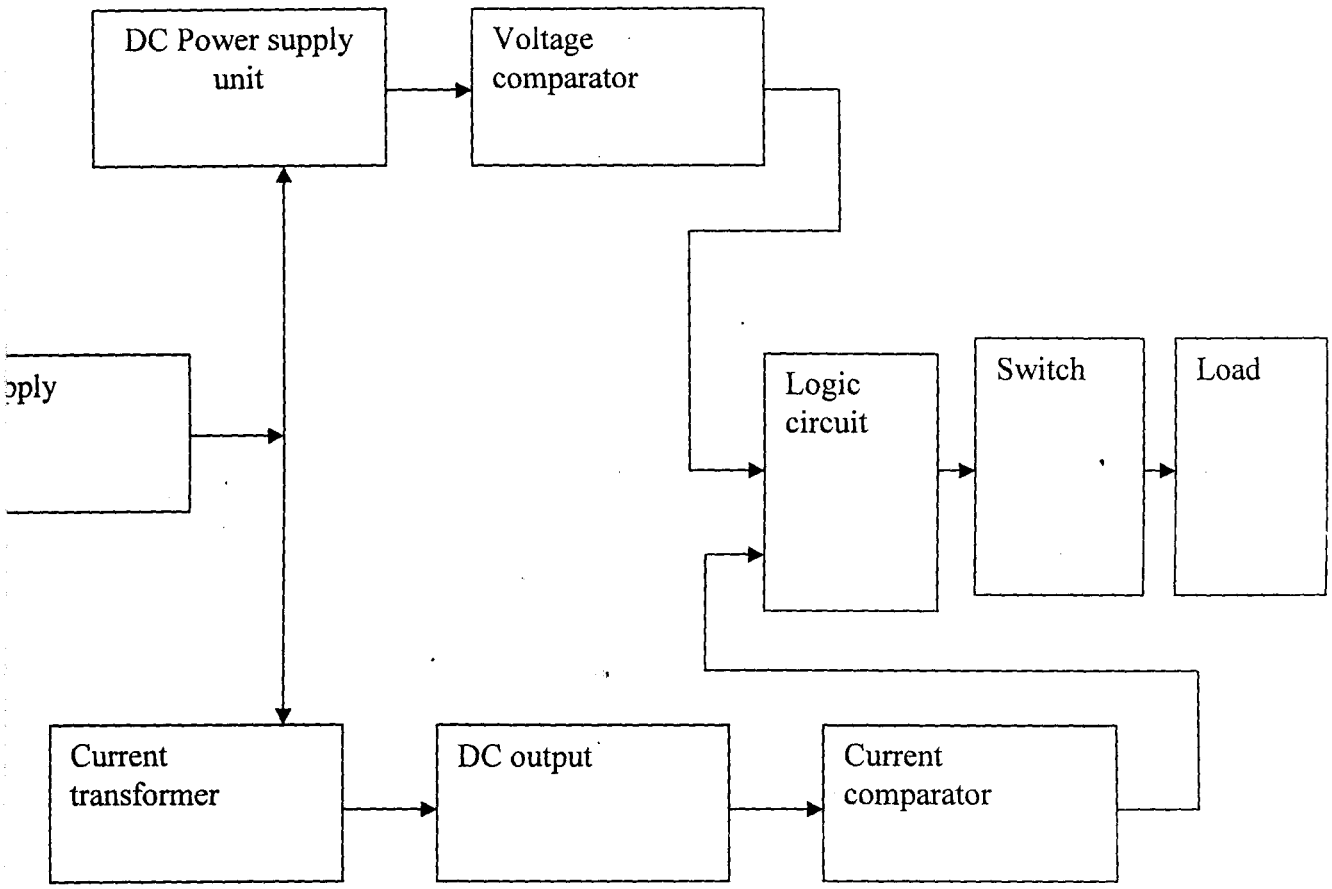
The current transformer monitors the set current by inducing voltage in its secondary in proportion to the load connected to the system. When the load exceed its set value ,the system switch off and go on standby-mode until the load is set to the required value.

Moreover, this system can only turn on when it is being set using pulse switch and turn off using also pulse switch. It is also range sensitive to any excess rise in voltage or current with the help of digital integrated circuit AND GATE that has output of 1 and 0[2]

1.8 Project's source of materials used and constraints.

With the assistance of friends inside and outside the department, most of the materials used for this project were purchased from the market and a few of them was obtain from old electronic panel/printed circuits

It was not easy getting the whole components at a time, as they were not readily available at the first attempt of purchase, and not easily getting the suitable components for the project, from the old electronic printed circuits.



Fig[?] Block diagram for over voltage/current protector

CHAPTER TWO

2.0 Literature Review

The problem of over voltage and over current became more pronounced when the transmission and distribution stations were far from the consumers. However, as a solution to these problems, one of the earliest attempts of obtaining regulated voltage and over current, employed a motorized system controlled by a control circuit and relay. some of the shortcomings are that ; it is costly, bulky and mechanical parts easily wear out[3]

2.1 Historical Background

Electricity was discovered by Michael faraday [1791-1867].After its discovery, voltage drop and resistances losses on the voltage d.c distribution circuit were the first set of problems encountered it is utilization..For electronic equipment to perform well, they need a certain stability of power supply. As a situation to these problems, however, a remarkable landmark was made by George Westinghouse by introducing the a.c [3] transformer .From this idea of the transformer, came out many approaches o f voltage regulation.

2.2 Previous works of others

Abnormal power rating operating condition are not desirable because electrical appliances are designed to operate at a specific voltage within some tolerance outside of which break down may occur .Those the present technological dispensation has changed voltage stabilization and protection techniques greatly.

As a result of these abnormalities in power system various devices and method have been developed to manage operations during this conditions, some of this

equipment are; Automatic voltage regulator, Resonant circuit voltage regulator, Relays, Fuses, Circuit Breakers, Voltage Stabilizer, Under Voltage and Over Voltage protector.

2.2.1 Automatic Voltage regulator This devices is used to control voltage such that whether there is a surge , sag or normal voltage supply .Other integrations included R resonant Circuit voltage Regulators and more recently the comparator types of voltage regulators. All these always have a fixed range of values that will produce output but this engage the devices on critical conditions [4]

2.2.2 Relays

Relays are employed where large amount of power is needed to switched .Hence, the relay are cascaded so a small relay switches. The power needed to drive a much larger relay and that second relay switches the power to drive the load, and also to de-energize the load via the first relay in abnormal voltage conditions. This was applied for the automation of heavy duty rotating machines like Industrial Motors but it's bulky and costly.

2.2.3 Fuses

Fuse are a safely device used to protect an electrical circuit from the effect of excess current. The vital component is usually a strip of metal that will melt at a given temperature .A Fuse is design such that the strip of metal can easily be placed in the electronic circuit. When there is an excess current surge through the circuit, the metal link will heat to its melting point and break. This action will open the circuit, stop the current flow, and this protect the circuit .However this have its limitations when there is over current.

2.2.4 Circuit Breakers

In hi gh-voltage circuit, that are subject to frequent interruption, and most in residential wiring, protection is provided by circuit –breaker s instead of fuses. Circuit breaker, switch designed to control an electrical power system by switching power on or off , under condition of normal or excessive load , in order to protect the electrical system in which it is connected. However its limitations is that

2.2.5 Voltage Stabilizer

Voltage Stabilizer operate in such a way that no matter the input to the Stabilizer once it is within its range of operation , it will bring out a constant value .but this have it limitation to power output

2.2.6 Under Voltage and Over Voltage protector

Moreover, attempt to bring this technology to domestic and small businesses were only justified recently. In the 1990s,most of the circuits used operational amplifiers as their automatic voltage regulator but the major short coming of this is that the comparators[operational amplifier] in the market are not ideal so these response are not sensitive enough especially for over current conditions. "Transistors as switches to drive the relay are found to be very competent and economical a factor taken advantage of in this project"

CHAPTER THREE

3.0 SYSTEM ANALYSIS AND DESIGN

The construction of over voltage/current cut –out devices consist of the following; power supply unit ,D/E 555pulse Generator, LM 324 Comparator, CD 4018 AND GATE, Transistor C945,Current Transformer, Relay 6V 10A.As show in the block diagram below

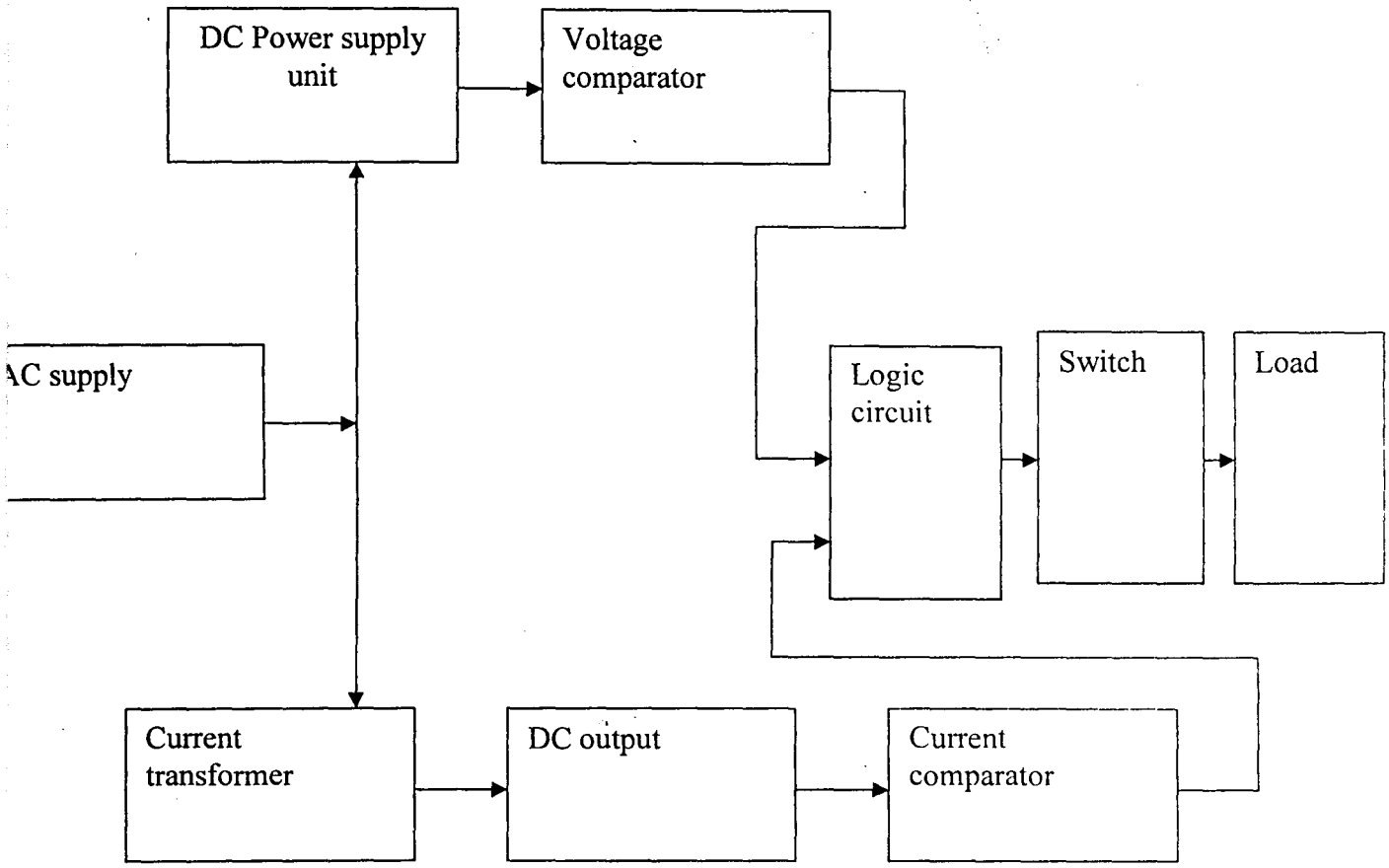


Fig 3.1 The block diagram of over voltage/current protector.

The input stage consist of 6V DC input, over voltage range 260V and above, over current range 8A and above which keep tag of the main rating of voltage and current.

3.1 POWER SUPPLY UNIT

The discrete components used in electronics designs will be damaged if operated with the 240V supply from the mains supply. Hence, there is the need for circuit that is able to output a voltage level on which the discrete components can safely be operated. The power supply unit perform this function which steps it to 9V at its secondary terminals [3][4].

Discreet electronics components are generally not powered by an AC voltage, hence there is need for rectification of the stepped down voltage from the transformer secondary

The rectification process is accomplished by a full wave bridge rectifier circuit comprising of four [4] rectifier diodes. The capacitor in the power supply unit is required in order filter out voltage pulsation or ripple components.

In an unregulated power supply, output voltage changes whenever input supply voltage or load resistance changes. The aim of employing the use of a regulator to reduce variation.

The circuit comprises of digital integrated circuit{IC'S} which produce output of high and low,0 and 1 with respect to their inputs. When there is a main supply of 220V ac , the step-down transformer TRI step it to 9Vac which then rectified, filtered by diodes D1-D4,and 25V 100uf capacitor..The circuit is designed to operate on 6V dc regulated supply ,by a regulator IC 7806 that takes a considerable range of input voltages and produces an output of which services as DC power sources to the electronic circuit[3].

3.2 DESIGN OF THE POWER SUPPLY UNIT

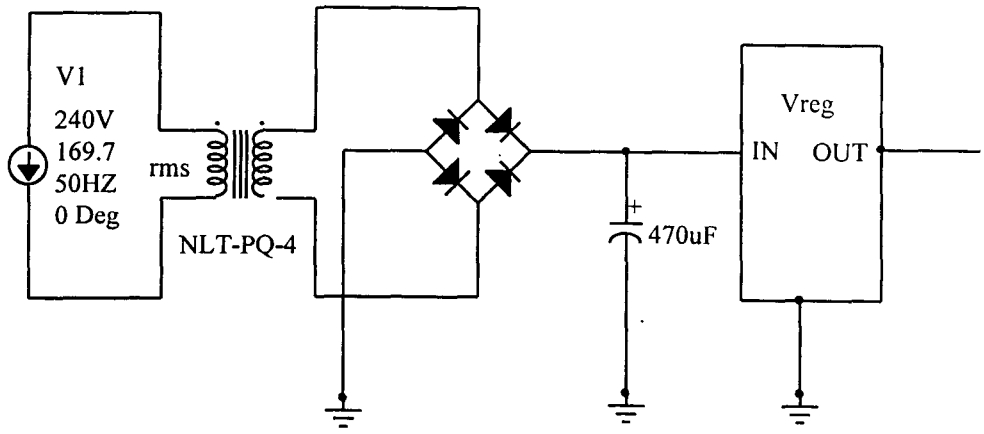


Fig 3.2 power supply unit

C=Idc

So any capacitor value greater or equal to 1000uf with a voltage greater than 9Volts, therefore a capacitor 470uf, 25V was used for better filtration

3.2.0 THE SENSING AND CONTROL UNIT

The sensing and control unit samples the input voltage and when the voltage falls outside the range, a signal is sent to the transistor which triggers and switches the relay off. This unit is built around an LM324 comparator Ic and variable resistor as well as fixed resistors which are used to set the required voltage unit to be detected by the comparator Ic.

A comparator is an electronics sensing devices that is use to sense when varying signal reaches same threshold value [3]. It is a circuit which compares the signal level or a voltage level. The LM 324 containing four operational amplifiers {quad op-amp} which have a very low operating voltage.

Its input terminal can be biased with a potential range of –0.3V to 30V having a power dissipated of 570MW [3].Its internal pin connection arrangement is shown in fig 1.2 below

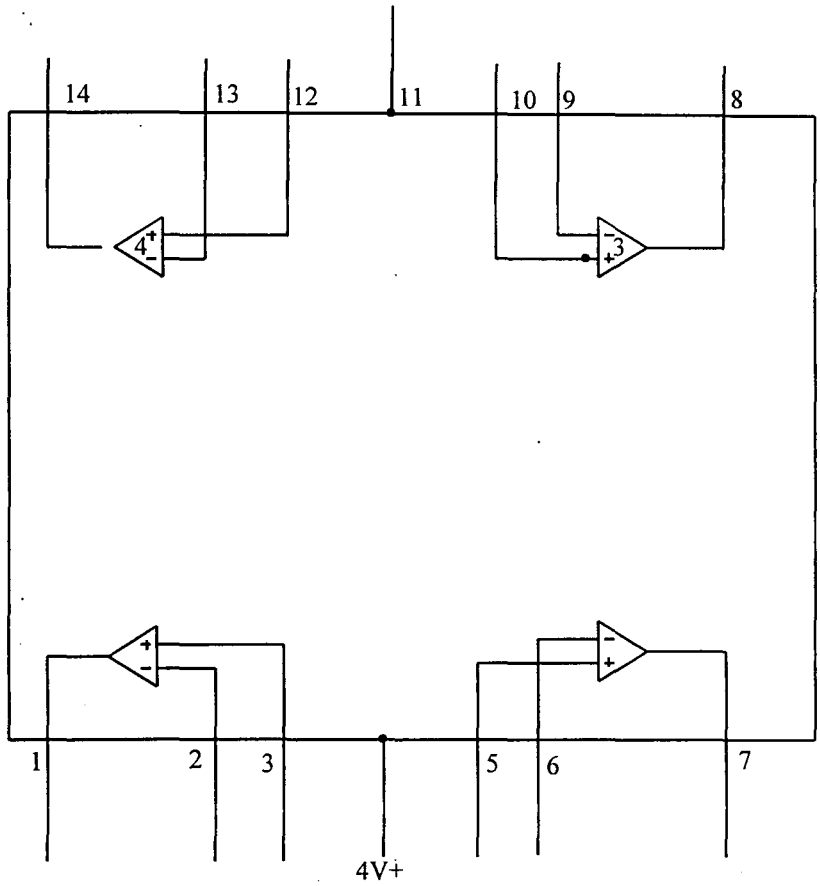


Fig 2.3 Internal circuitry of LM 324

Voltage comparators are not perfect devices and in some or most instances may suffer from the effect of a parameter known as the input offset voltage. This occurs when the input voltage changes very slowly. The net result of this is that the transistor output does not fully turn ON or OFF when the input voltage is close to the reference voltage.

This effect can be countered by adding hysteresis to the circuit. This causes the reference voltage to change when the comparator output goes high or Low. This bring

about the need to add an external device [current transformer] between the comparator output and the positive input creating a balanced feedback loop[3].

3.2.1 The 555 Timer

The 555 Timer is a stable device for generating accurate oscillations. The 555 Timer IC is configure to operate in a latch form, when the switch S1 is pressed the output pin 3 of the time goes high keeping the pin3 and pin5 [non inverting inputs] of lm 324 operational amplifier high to about 4.80v which services as a reference voltage to the IC's[A and B][5]

3.2.2 Comparator

The output of comparator goes high when the non-inverting input voltage is greater than inverting input voltage otherwise low. The comparator services as a voltage sensor that senses the input voltage from unregulated supply connected to inverting input via 10kn potentiometer. When the voltage from unregulated D.C supply exceeds the required set input voltage with respect to required A.C voltage for normal operation of appliance [220-240],the inverting input voltage exceed the non-inverting input voltage, therefore toggling the state of op- amp from 1 to 0 .Meanwhile the output of comparator A is not connected to pin 1 input of AND GATE C so that when the second comparator B goes H

High with comparator A the NPN transistor C 945 TRI, turns on and turns on relay RLI, Thereby turning on the channel 1 sockets which indicates by led 2[red][5].

3.2.3 Current Transformer

The current transformer TR2 which its primary windings is connected in series with the AC line. Induce a voltage to its secondary winding in proportional with the load

resistance at very low resistance load, the output of current transformer TR2 rises which then rectified, filtered by diodes D6-D9 and capacitor 16v, 470uf.The '5watts 220n' resistor helps to limit excess rise in voltage to avoid damage to comparator B. Then rectified dc is then feeding into the inverting input pin 6 of the comparator so that rise in load current which produces the input voltage to pin 6n via TR2 secondary turns control the output state of comparator B. At low current load the output pin 7 of comparator B goes high otherwise low.

Therefore when the voltage supply to the load and current drawn by load is at normal state pin 1 and pin 7 of op-amp A and B goes high, making the two inputs of AND GATE'S C and D high and its outputs pin 3 and 4 high keeping the two AC output channels on by energizing relays RLI and RL2[5]

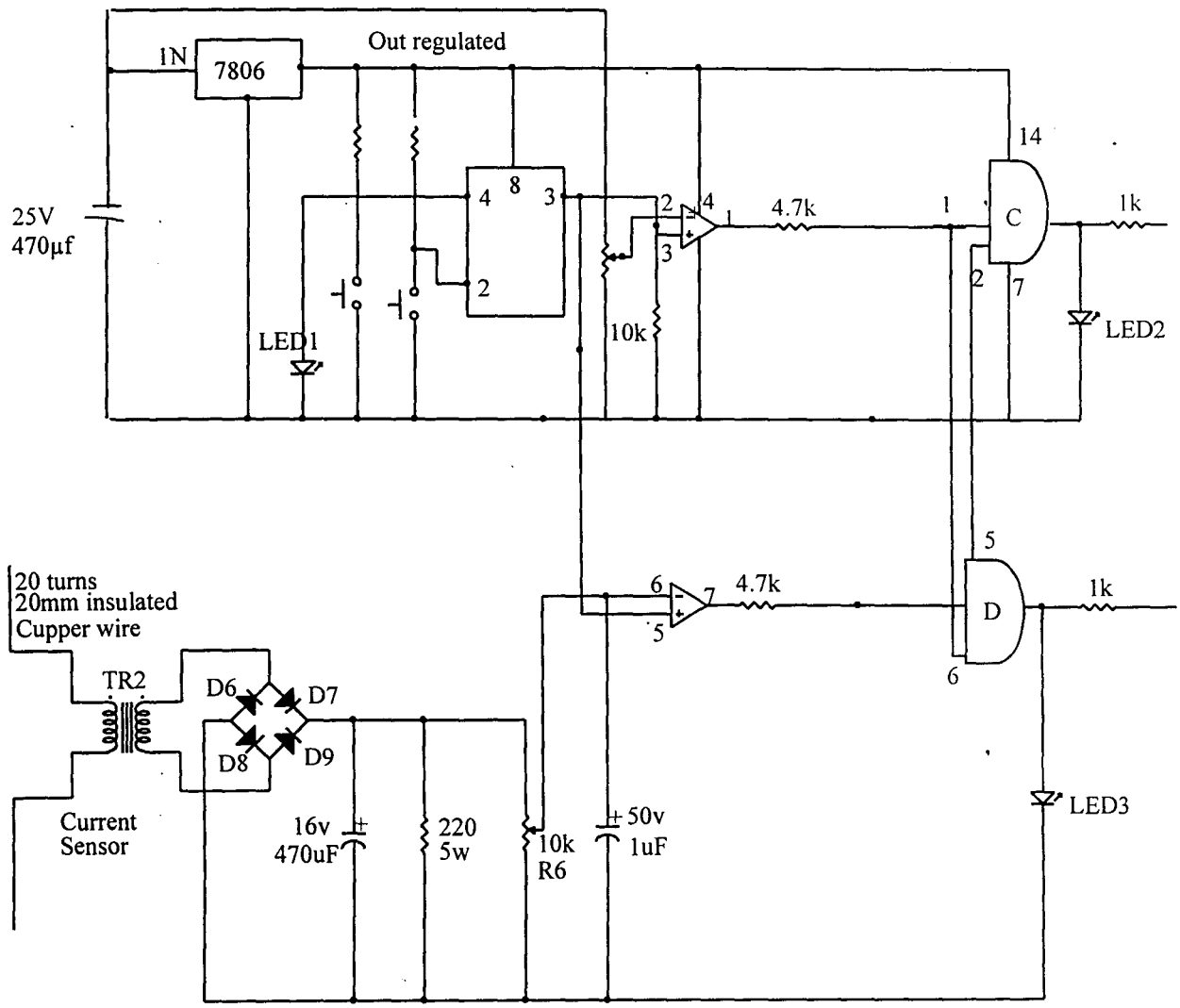


Fig 3.3 circuit diagram of sensing and control units

3.2.5 OPERATION

When the switch S1 is pressed down the 555 Timer IC output goes low making the non-inverting inputs of IC A and B low. When this is done the LED1 links showing that the system is to go on standby mode .The system goes on standby when ever is being powered, so irrespective of power failure the system will not come on by itself when the power supply is restored. It can only come on when the switch S2 is pressed [5].

3.2.6 OBTAINING THE VALUE OF THE VARIABLES

Let I=1Ma , Vcc=9v

Applying ohm's law yields

V=IR

$R=\frac{V}{I} = \frac{9}{1mA} = 9Kn$ ..... (1)

Nearest preferred value is 10kn, variable nVrI= Vr2 = Vr3 = 10Kn

The outputs from both comparators are fed into an AND GATE [CD 4081] which services as a control device. When either of the outputs from the comparators is HIGH; The output of the AND GATE'S or control device goes HIGH, thereby triggering the switching circuit. The 4081 IC used in this project is a quad-2 input AND GATE'S and are used for the operation. Below is the internal circuit of the 4081

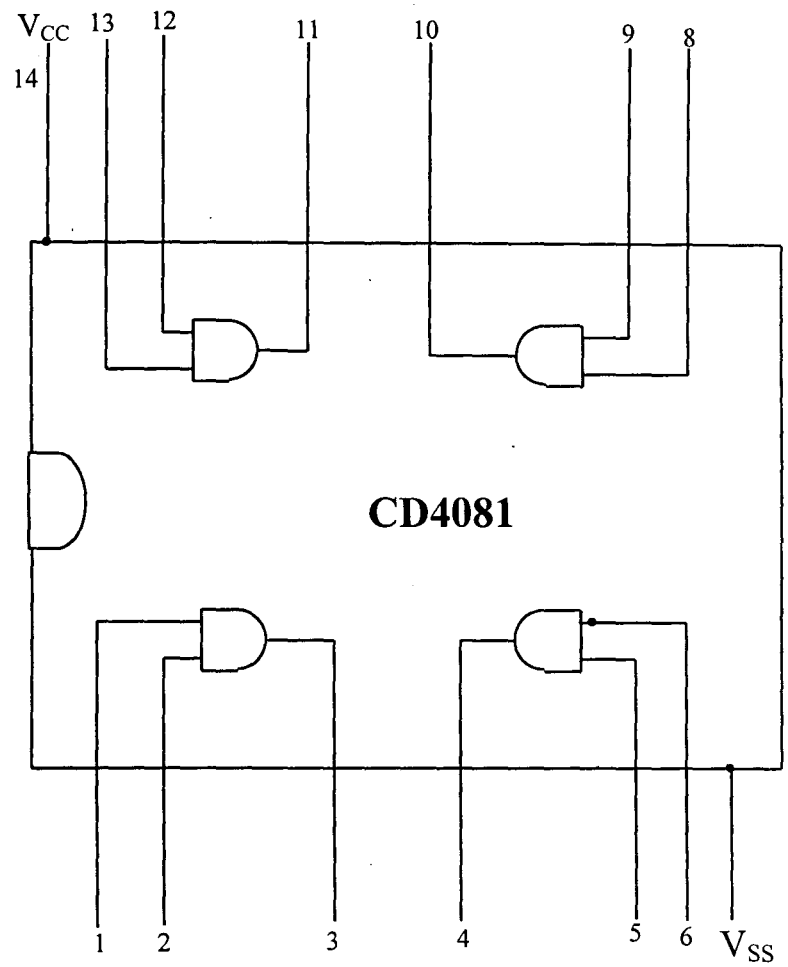


Fig 3.4 CD 4081

There are two LED'S included in the sensing and control unit. One indicates the over voltage level condition while the other indicates an over current level condition. Attaching to the LED'S are current limiting resistor which are basically for protection against excess current in rush to the LED'S.[3]

3.3 CALCULATION OF THE LED CURRENT-LIMITING RESISTOR

Let LED current [I] =10Ma

When the comparator is HIGH, Vo = + Vsat = 11V, Vd=2V

I LE

= 11- 2

10mA

= 900

R limiting = 900n

The nearest preferred m resistor value is 1kn

3.4 STATE OF THE IC'S OUTPUTS

~~Fig~~ ~~Table~~ ?

CLK	A	B	C	D	OUT
HIGH	1	1	1	1	ON
LOW	0	1	0	0	OFF
LOW	1	0	0	0	OFF
LOW	0	0	0	0	OFF
X	X	1	0	0	OFF

Fig The Truth Table of CD 4081

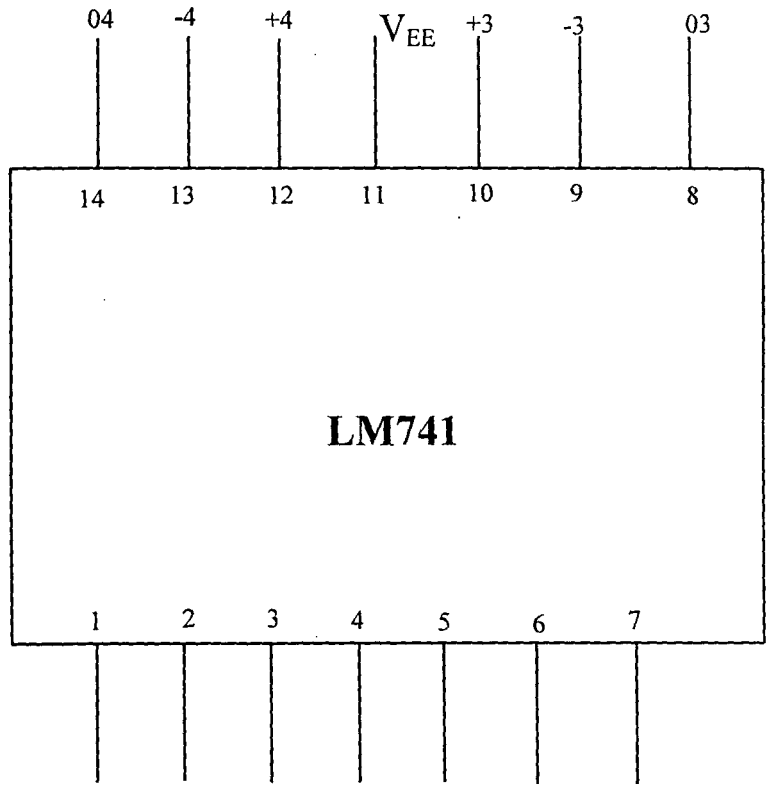


Fig 3.6 Circuit of operational Amplifier

From comparator A

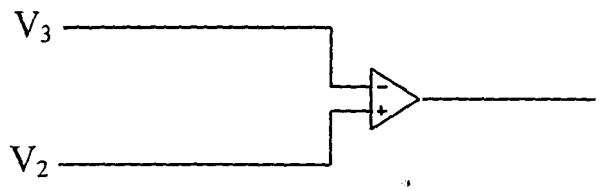


Fig 3.8 comparator A

V3 V2 output 1- first condition

V3 V2 output 0- second condition

V6(V)	RL	I(A)
4.80	250	2.0

V3= 4.80V output voltage of NF 555 when powered with 6V DC provided by the manufacturer

Therefore to obtained V2, the maximum allowed AC voltage is considered and rejected AC voltage for safety of appliances

V2= 4.8 is set at 250V, the below formula is used

250V gives 4.80V

250V will gives $\frac{220 * 4.8}{250} = 4.224V$

$= 4.2V$

Therefore V2 = 4.2 at 220V are supply.

The LED 2 and 1k base resistor keeps the base current Ib of transistor at 1Ma

The load resistance that is relay resistance is 700n

Therefore Ib = ImA

Rl = 700n

Vcc = 6v

B = 100 For small signal transistors.

Therefore $\frac{Ic}{IB} = B$

Ic = B . IB = 100 * 1 = 100Ma

Considering comparator B

V5 = V3 = 4.80V

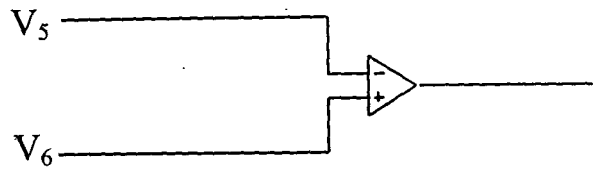


Fig 3.8 comparator B

Experimentally R6 is obtained so that V6 is 4.80V when a load current of 2.0A is applied. Therefore when the current exceeds 2.0A ,V6, V5 ,turns the state of V7 from 1 to 0, keeping the system on standby mode.

The minimum load resistance that can be applied to the socket is 100n for inductive load but greater than 250n for resistive load.

Therefore the power rating of load that can be connected to the system is

P= I'2R = 2 * 250 = 1000w

This power is suitable for any electronic devices since most of the electronic devices like computer monitor; CPU etc are rated less than 1000w each.

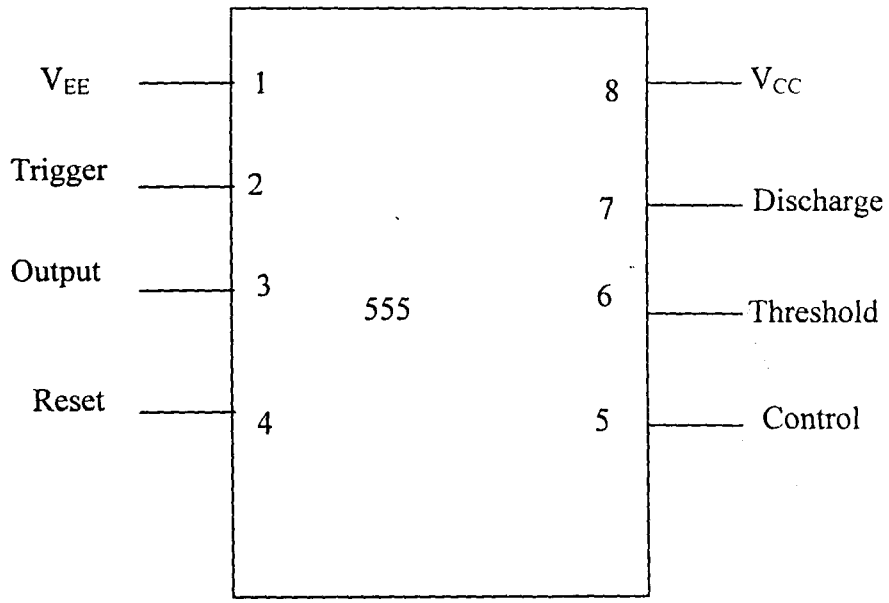


Fig 3.9 555 Timer

Fig 4.0 AND GATE C 945

3.5 SWITCHING CIRCUIT

A transistor when configured or biased to operate in a saturated and cut off region of its operating characteristics acts as a solid-state switch. The switching circuit is built around a transistor which is biased to operate in saturation and cutoff regions. When the

transistor is supplied the base drive current from Q output, it triggers the transistor from the off state into the ON conducting state[4][6], thereby energizing the relay which now opens the contacts of the socket and cutting off the supply to the load. This can only occur when there is an over voltage or over current condition detected by the circuit

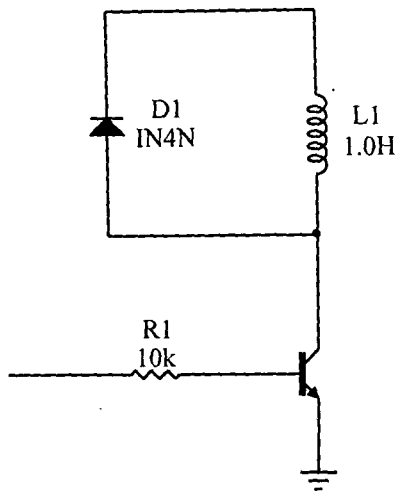


Fig 4.1 switching circuit

In the switching unit, the 12V relay serves as the collector load of the transistor. This relay is 12V dc, 10A with a coil resistance of 400 ohms. A diode is connected across the relay coil to safe guard against inductive back emf of the relaycoil. The transistor used is the C 945 NPN transistor with current gain, hfe =200, Vbe [sat] = 0.7n and the maximum collection current, Ic = 100Ma

1.

$$Ib = \frac{Ic}{Hfe}$$

$$= \frac{100mA}{200}$$

$$Ib = 0.5mA$$

From analyzing the current diagram, the base of the transistor is supplied by the output of the logic phase selection circuit. The outputs are high with output between 3.6v and 12 v.

From the base current, Ib = 0.5mA

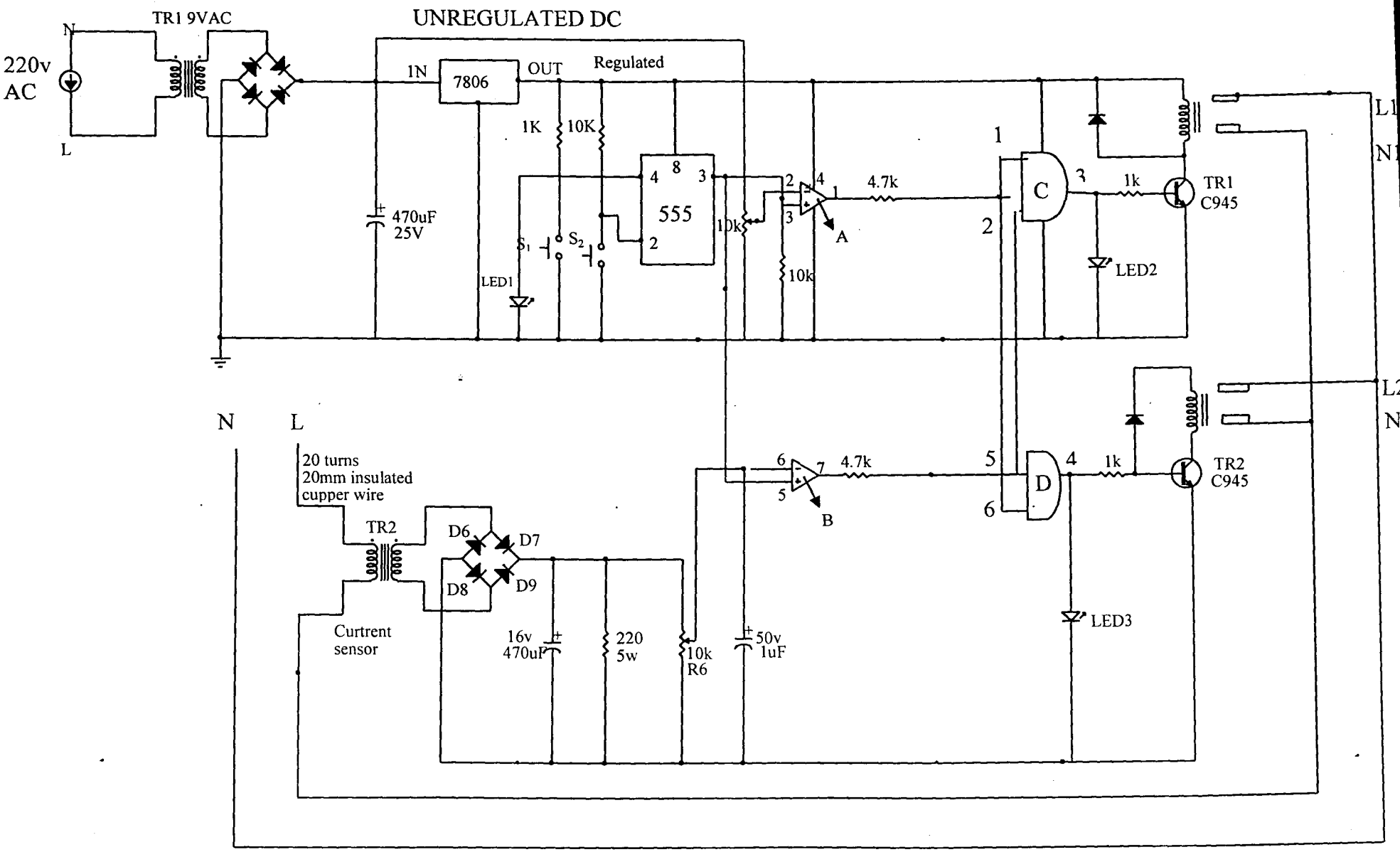
Then the base resistor can be determined.

$$Rb = \frac{Vo - Vbe[sat]}{Ib}$$

$$= \frac{12 - 0.7}{o.5mA}$$

$$= 22.6kohms$$

Therefore resistor standard value of 20k was used as the base resistor for the transistor.


TR1 9VAC
UNREGULATED DC
220v
AC
N
L
1N
7806
OUT
Regulated
1K
10K
470uF
25V
555
S1
S2
LED1
10k
4.7k
A
B
C
D
1k
TR1
C945
LED2
TR2
C945
LED3
20 turns
20mm insulated
cupper wire
TR2
D6
D7
D8
D9
Curtrent
sensor
16v
470uF
220
5w
10k
R6
50v
1uF
L1
N1
L2
N2

CHAPTER FOUR

4.0 CONSTRUCTION AND TESTING

CONSTRUCTION OF THE CIRCUIT

Before the construction proper, the power supply unit, the sensing and control unit [over voltage/current], and the switching unit were simulated non computer using the electronic workbench and they were working as expected. In addition, after calculating the required component values for this project, the components were bought and firstly arranged on project board [bread board] in accordance with the circuit diagram, and it work fine. the whole circuit was transferred to a vero board, soldered and tested okay to satisfaction.

The test aims at obtaining the over voltage condition level and over current condition level at which appliance will either connect to power supply or disconnected to power supply and go on standby mode

Results' Tabulation

	Primary and secondary voltage (v)	Current range (A)
Over voltage	270 and 19.23	
Normal voltage/current	240 and 17.1	8-10
Over current		10-12

4.1 DISCUSSION OF RESULTS

4.2 OVER VOLTAGE CONDITION

When the supply voltage was at 250volts and above, the rela y became de-energized as was observed. Them normally open contacts of the relay remain open

4.3 NORMAL VOLTAGE/CURRENT CONDITION

When the supply voltage from the mains was at this range [190-240] volt, 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.

4.4 OVER CURRENT CONDITION

From the n test, it was not observed that current range [10-15] amperes, the relay switch was de-energized. The normally open contacts remained due to the over current.

4.5 CASING

The casing for the project is made of ply-wood which is well dimensioned and earthed. Holes are drilled for the switch, meter, screwing down of the circuit board and transformer to the floor the casing. The material was chosen because it has good finishing and less cost effective

4.6 TESTING

The initial testing was carried out on the various components used for this project with the aid of the multi-meter .the second stage of testing was carried out when the components were arranged on the breadboard by adjusting the potentiometers and observing the effects on the output as indicated by the light emitting diode indicators and energizing relay before transferring the circuit to the vero board.

The final test was carried out on the project after it has been coupled. This test was carried out using the variance in the machine laboratory of the electrical/computer engineering department

CHAPER FIVE

5.0 CONCLUTION AND RECOMMENDATION

CONCLUTION

The design and construction of over voltage and over current protection was successfully carried out. The results from the testing of the project show that the device will compete well with other protective devices based on the following points

1. During over voltage condition, it de-enregizes[switches off]the load automatically and goes on standby mode ,thereby giving it protection against destruction

2. During normal voltage /current condition, it energizes [switches on] the load, thereby giving it the enablement to operate successfully.

3. During over current condition, it also de-energizes [switch off] the load automatically and goes on standby mode, thereby protecting it against destruction.

In conclusion, the switch can only be on when the two conditions of normal voltage and current are met. The project has shown the possibility of designing and constructing a low-cost device which can be used to protect electronic appliances against abnormal voltage/current conditions effectively

5.1 IMPROVEMENTS

1. This project can be improved upon as higher voltages can also be regulated for industrial appliance

2. Alarm unit can be incorporated to sound a warning if the operating conditions fall below or above the desire operation voltage/current range

3. Microcontroller can be incorporated to put the system' on' automatic, when it goes on standby mode instead of resetting it

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