Design and Construction of an Under Voltage /Over Voltage Control Switch.

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IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF ENGINEERING (B. ENG) DEGREE IN ELECTRICAL AND COMPUTER ENGINEERING

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ATTESTATION

This is to certify that this project titled "DESIGN AND CONSTRUCTION OF AN UNDER VOLTAGE/OVER VOLTAGE CONTROL SWITCH." Was carried out indeed by the student under the supervision of Mr. Nathaniel Salawu and submitted to the Electrical\Computer Engineering department, Federal University of Technology Minna, in partial fulfillment of the requirements for the award of Bachelor of Engineering (B. Eng) degree in electrical engineering.

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ENGR. M. D. Abdullahi Head of Department	Date
External Supervisor	Date

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Last but not least to the administration, staff and students of F.U.T Minna, I've learnt a graet deal from all of you. Thank you and I am very grateful for the opportunity you gave me. THANK YOU ALL.

DEDICATION

I dedicate this project work to my father Ntufam John Achot Okon and my number one fan and friend Mrs. Millionet. A. Okon my mother.

ABSTRACT

This project was carried out with the aim of designing and constructing an Under Voltage\ Over Voltage Control Switch. Using components that can be obtained locally in the market. This device would provide protection against power surge, under voltage conditions for small business and domestic equipments. It uses a simple relay with normally open contacts, and an accompanying control circuit which sets the normal operation of the relay within the range of 180V-260V. Normal operation meaning that the relay contacts will remain closed within this range of mains power supply from Power Holding company of Nigeria (P.H.C.N).

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CHAPTER ONE

1.0 INTRODUCTION

There are as many electrical devices today as there needs. Almost all human activities are dependent on electrical machines and device, which use electrical energy in their operations. For instance, washing machines, blowers, pumps, compressors, refrigerators and a number of industrial drives and small business equipment which convert electrical energy to mechanical and other forms of energy in their functions.

These equipments rely on electrical supply from the local or national power authority (PHCN) in this case.

1.1 Abnormal Power Operating Conditions.

Ideally, electrical supply should be constant without any interruption or voltage variations but in practice interruption and voltage variations are inevitable due to the following situations that arise during power transmission and distribution

1. Power interruption
2. Under voltage conditions.
3. Over voltage conditions

1.1.1 Power Interruption.

Power interruption may be due to transient fault on any part of the power system which may be caused by lightening strikes overload conditions and short circuits in transmission and distribution equipment and lines.

When this situation occurs the protecting device (relays and its supporting circuit) are energized thereby cutting off power supply to the affected part and may immediately restore power once the result is cleared.

Power interruption is undesired because it can damage some equipment for example electromechanical compression and piston type equipment; when power supplied to the compressor type equipment is removed and then restored immediately there would be vibrations in the system (equipment), because the compressor system pressure is not yet equalized. This can in effect damage the piston of the equipment.

1.1.2 Under voltage condition.

Under voltage condition may occur when there is a fault or break down in the transmission system and also when the demand for electricity is at its peak. This condition is dangerous to such equipment as refrigetor, vacuum cleaner, washing machines, freezers, air conditioners and finding machines. Just to mention a few in effect there will be an increase in line current and because the voltage is low the system draws more current from the line to compensate for the drop in voltage. This leads to overheating and would cause a fine if not checked.

1.1.3 Over voltage condition

Over voltage condition could be caused by either lightening or switching over voltages. Lightning over voltage is as a result of a natural phenomenom while switching over voltage originates from the connection and disconnection of circuits breaker contacts at switching.

The effect of over voltage is hazardous to life and equipment. over voltage will cause increase in torque in electric motors which may result in possible damage to all the mechanical couplings of the appliance other loads such as water heater electric cooker. toaster, over voltage conditions will cause the heating element to burn out quickly. Life expecting of electronics component will decrease. Filaments of fluorescent, are incandescent lamps and bulbs set destroyed immediately there is an over voltage condition.

1.2 Developments.

Abnormal power rating operating conditions are not situations desirable because electrical devices are designed to operate at a specific voltage with some tolerance outside of which breakdown may occur.

Due to these abnormalities in power system various devices and method have been developed to manage operations during this conditions some of these equipments are.

a. **Uninterrupted power supply (UPS)**

This supplies D.C power from a bank of batteries to an inverter which converts D.C to A.C, when the A.C supplied by the national electric authority falls. Its limitations are that it can only be used for a limited time and it is quite expensive to install or maintain.

b. **Solar Cells.**

This is used to produce power from solar energy which is converted to electrical energy which charged a tank of batteries that supply D.C to an inverter which converts D.C to A.C.

This device is expensive to install and has limited power supply as well as occupies a lot of space.

c. **Voltage Stabilizer**

It is a common practice to a voltage stabilizer to correct voltage fluctuations. This also is limited in power output.

1.3 Focus of Project.

There is need however for a voltage protection that satisfies the following conditions:

1. Economically affordable even by the low income earners.
2. That is of comparatively simple construction.

3. Able to efficiently discriminate between normal and abnormal system voltages.

4. Cut-off power to the equipment protected when there is voltage fluctuations that are severe.

5. Restore power to the appliance protected as soon as power system returns to normal.

This project is designed to perform the aforementioned objectives.

The over voltage/ under voltage switch is a protective device for electrical devices found and used in the small business and domestic sector.

The switch automatically cuts off power to the appliance for supply voltages higher or lower than (+_ 20%) of the rated voltage (220 volts) and automatically restores power when voltage supply is normal. Small business equipments as mentioned in this project shall include equipments viz;

a. Grinding machines

b. Air conditioners

c. Photocopying machines/printers

d. Refrigerators as well as other equipments found in this sector excepting computers and other data storage devices (since an uninterrupted power supply (UPS) should be used in accompaniment).

Cost Analysis

In this project the materials used were obtained locally while other components were gotten from friends and old electronic equipment. Their prices are as tabulated in the as tabulated below.

The total cost was comparatively cheaper than the market price of regulators and stabilizers. This suggests that the economic goal of this project is achieved.

Table 1: Cost analysis table

Descrition	Nos	Unit cost	Total cost
Step down transformer 240-12V (a.c)	1	N150	N150
555 timer	1	N60	N60
Relay	1	N80	N80
Transistor	3	N20	N60
Resistors	12	N20	N240
Rectifier diodes	6	N5	N30
Light emitting diodes	6	N5	N30
Zener diodes	2	N10	N20
Capacitors			
2200 µF	1	N80	N80
1000 µF	1	N60	N60
100 µF	1		
10 Mf	1		
0.01 µF	1		
Vero board	1	N120	N120
Solder	½ yard		N80
Casing			
TOTAL COST			N1010

The involvement of students and lecturers in the school especially in the Electrical/Computer Department is admitted and also well stated in the acknowledgement.

CHAPTER TWO

Literature Review

Electricity was discovered by Michael Faraday (1791 – 1867). Economy of scale and relative continuity all combined to provide the needed support for the central station electric service, which was the idea of Thomas Edison.

Voltage drop and the resultant loses in resistive parts of the low voltage d.c distribution circuit were the first limiting factors encountered, and also the problem of voltage regulation and control. However, as a solution to these problems a remarkable land mark was made by George Westinghouse who introduced the A.C transformer.

Developments in AVRs (automatic voltage regulator) began by making use of motorized system controlled by an accompanying circuit to select tapping on the secondary of an auto transformer an even input is maintained but the bulkiness and cost of this system was a great disadvantage.

Other developments included the resonant circuit voltage regulators, and more recently the comparator types of voltage regulators.

However, voltage regulators do not disengage the device on critical voltage conditions. Early modifications in the automatic voltage regulator circuit, to convert them to switches were carried out by companies like General Electric and Asea Brown Boveri (ABB).

In this case where large amount of power needs to be switched the relay is employed. 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 he load, and also de-energize the load via the first relay in abnormal voltage conditions. These were applied for the automation of heavy duty rotating machines like industrial motors.

However, attempts to bring this technology to domestic and small business (low voltage users) were only just recently started. In the 1990s, most of the circuits used operational amplifiers as their automatic voltage regulator parent, 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 under voltage 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 Theory of Design

This chapter presents theory of operation of the different components (or group of companies) used in this project. The principle of their operations is exploited in the design of this circuit.

The block diagram of the over/under voltage control switch is shown in figure 3.1. It consists of the following:

1) Two transistors switch Q1 and Q2. (See Figure 3.2). Q2 is not active during normal and under voltage conditions but is active during an over voltage conditions, by cutting off power to the relay by disabling Q1 "by bringing point (D) to ground". Or acts as the main driving switch to relay during normal operation and also cut's off power to the relay during the under voltage condition.

2) And a delay circuit to institute a ten seconds delay from power down condition, so the equipment protected does not receive supply immediately after a power interruption.

3) And an electromagnetic relay that controls the supply voltage to the main load via its contacts.

In this project, the technique applied is such that the relay is energized throughout normal operation of the over voltage/ under voltage control switch and its normally open contact closes, supplying power to the load or equipment projected and de-energized when there is over voltage or under voltage from the supply, cutting off power to the load or equipment protected.

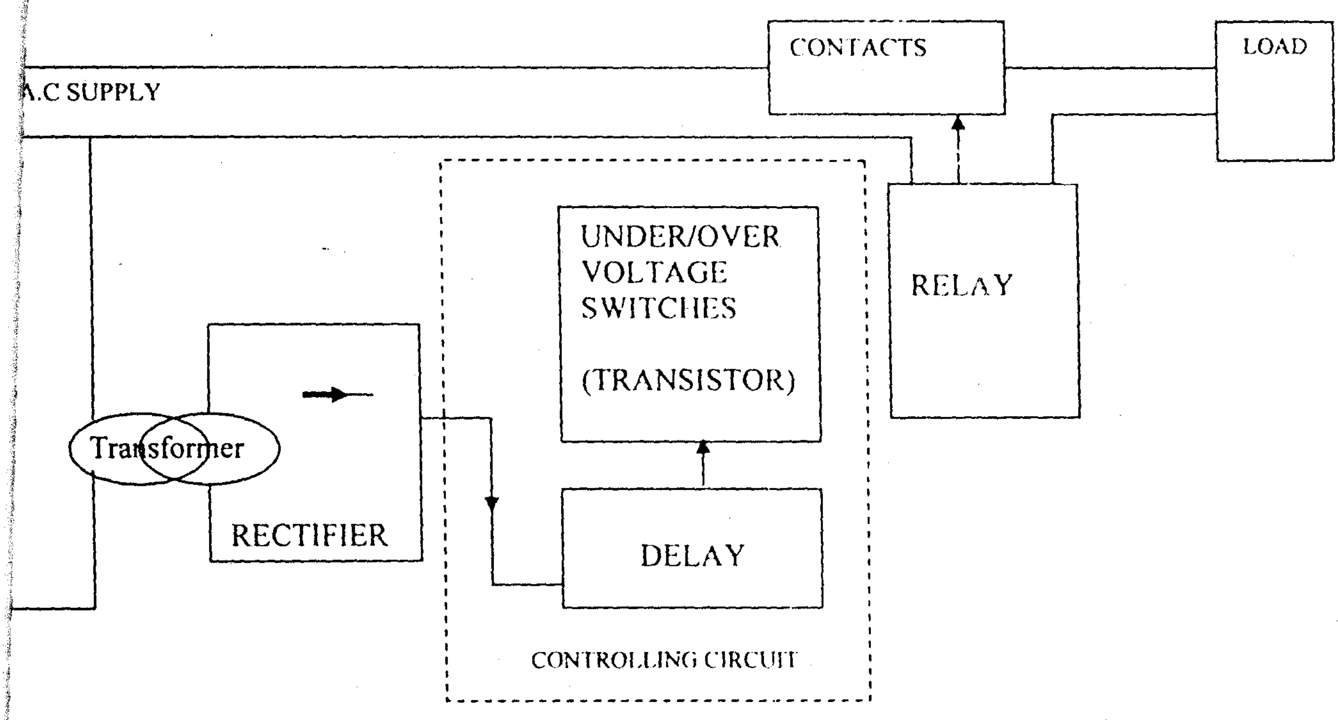


Fig 3.1: Block diagram of under-voltage/over-voltage control switch

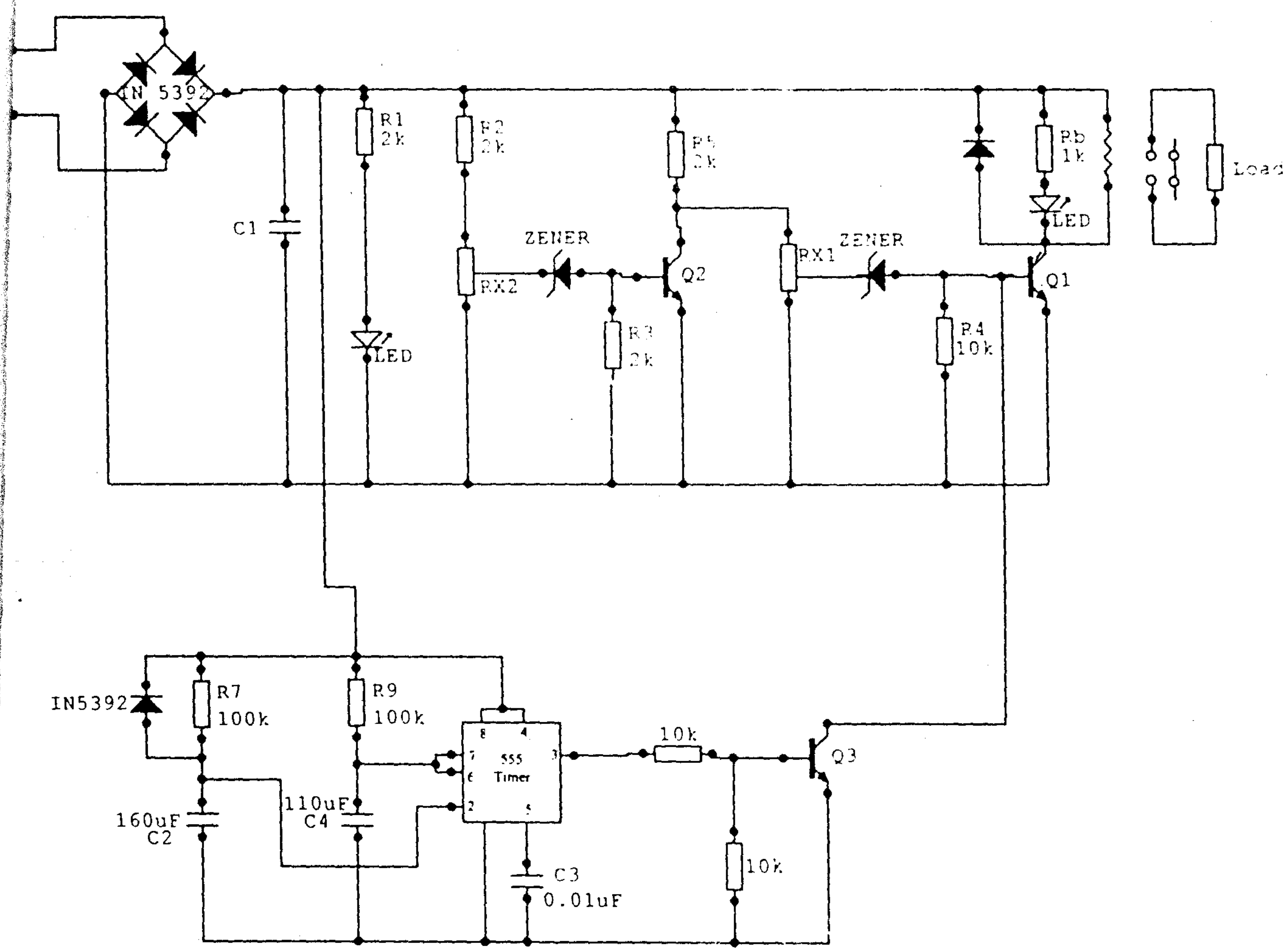


Fig 3.2: Circuit diagram of the under-voltage/ over-voltage control switch

3.1 System Specification

3.1.1 Power Supply

Power supply is necessary for the conversion of the A.C voltage from the electrical power utility company (P.H.C.N) to the D.C voltage required in electronics and electrical equipment. The transformer steps down the A.C and the voltage is then rectified by a bridge rectifier then smoothened by a filter circuit (capacitor).

Power supply is required for the various components:

a) 12 volts d.c to each of the transistor switches section.

b) 12 volts d.c to the delay circuit

c) 12 volts d.c to the relay coil

3.1.1.1 Voltage classification

The different Voltage ranges and their respective relay contact is shown in table 2 below.

Table 2: Voltage ranges and relay contact actions

	Primary	Secondary	
Normal Voltage	180 - 260v	9 – 13v	Relay coil is energized. Contacts closed. Power is supplied to the appliance/ load
Under voltage	0 – 180 v	0 – 9 v	Relay coil is de-energized and contacts open, power is cut off from appliance/ load.
Over voltage	Above 260 v	Above 13 v	Relay coil is de-energized. Contacts open. Power is cut off from appliance/ load.

3.1.1.2 Step down Transformer

A 240/12v transformer is used to step down the 240 volt a.c at the secondary.

The transformer uses a full wave bridge rectifier for rectification.

3.1.1.3 Full – wave Bridge Rectifier

The rectifier converts the 12 v a.c into d.c supply; it consists of four diodes as shown in Figure 3.3a. During the positive input half cycle terminal M of the secondary is positive and N is negative as shown in Figure 3.3b. Diodes D1 and D3 become forward biased (ON) whereas D2 and D4 Are reverse biased (OFF). Hence current flows along MEABCFN as shown in Figure 3.3c producing a drop across load R_l.

During the negative input half cycle secondary terminal N becomes positive and M is negative now. Diodes D2 and D4 are (ON) while D1 and D3 are (OFF). Current flows along NFABCEM as shown in Figure . Hence voltage drops across the load R_l.

3.1.1.4 The Capacitor Filter

The capacitor filter converts the full wave rectified d.c signal into a smoothened d.c voltage. The important parameters of the capacitors are its working voltage and its capacitance value. The working voltage must be greater than the transformer secondary voltage, (at least twice the secondary voltage). The capacitance value determines the amount of ripple that will appear in the d.c voltage when current is being drawn from the circuit.

3.1.2 The 555 Timer

The 555 timer is a stable device for generating accurate time delays or oscillations. Additional terminals are provided for triggering or resulting if need be. In its monostable mode of operation, the time is precisely controlled y one internal resistor and one capacitor.

Triggering of the timer is achieved by supplying a voltage to Pin 2 less than 1/3 of the supply voltage. After triggering the output can source up to 200mA or drive T.T.L directly. The connection for monostable operation is shown in Figure 3.4.

The timing formula for a monostable operation is obtained from relation

$t = CR\log_e 3$

$t = 1.1\ CR$

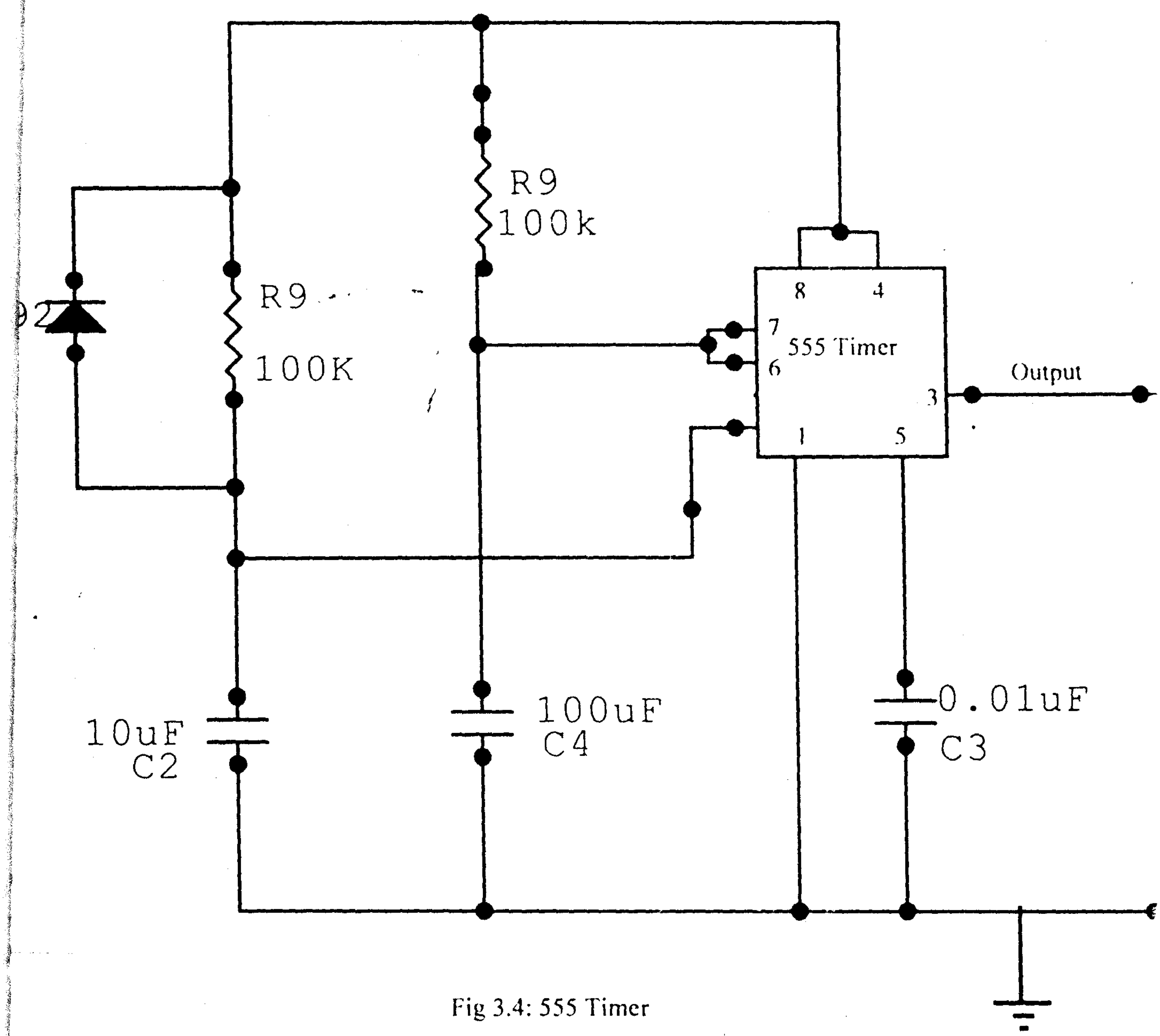


Fig 3.4: 555 Timer

3.1.3 Switching Device

The switching action of transistors switch is the main technique employed in this project for both sensing voltage conditions and driving the relay which is the principle switch that is controlled by the electronic circuit made up of transistors, resistor and a timer circuit.

3.1.3.1 Basic Principle of Relay

A relay is a device operating in response to variation in current, voltage, power, frequency or some other electrical variables.

The operation of a electromagnetic relay depends on the interaction of magnetic field set up by a fixed coil carrying an electric current and a moveable steel armature.

If there is any change i9n the main current circuit, the relay coil is energized and pulls the armature is pulled to either close the contacts or open that contacts. This basic principle of relay is what is applied n this project. For the switching action a simple relay is shown in Figure 3.5.

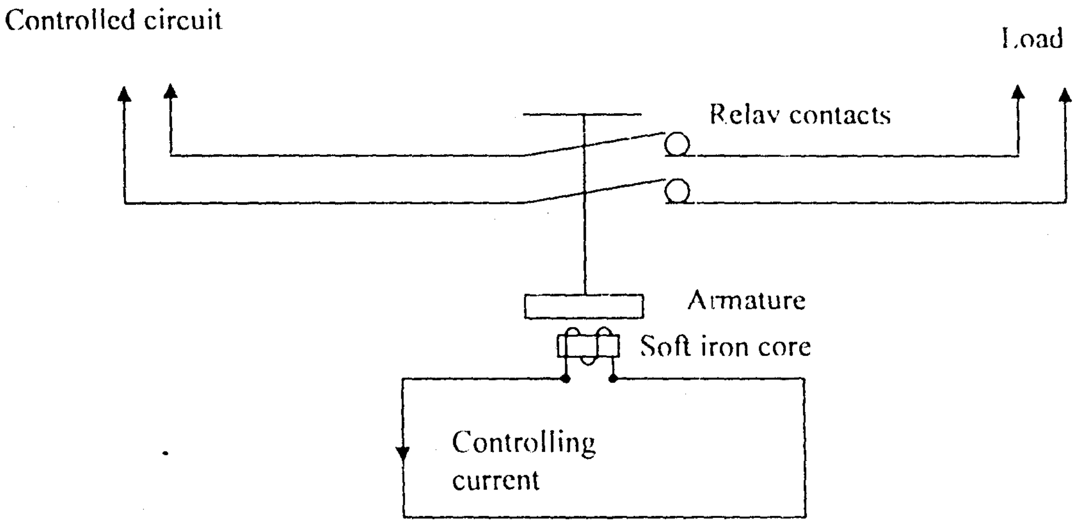


Fig 3. 5 Simple Relay

3.1.3.2 Basic Transistor Switch

A junction transistor is a combination of two junction diodes and consists of either a thin layer of P-type semiconductor sand witched between two n-type semiconductors, to give an n-P-n transistor or vice-versa to give what is referred to as P-n-P transistor.

As a switch a transistor is normally operated in the cut off region as an open circuit, and in the saturation region as a closed circuit, and in the saturation region as a closed circuit. This principle of transistors operation is what is applied in this project. The transistor used is the 25C815GR Silicon, nPn. The minimum base current (IB) to drive the transistor is: given by

IB = IC Sat

hfe = forward current .. [2]

The transistors bias is controlled by the different rheostat settings for each sensing for each sensing section and zener diodes which is used as "sub tractor" for each transistor as shown in Figure 3.6.

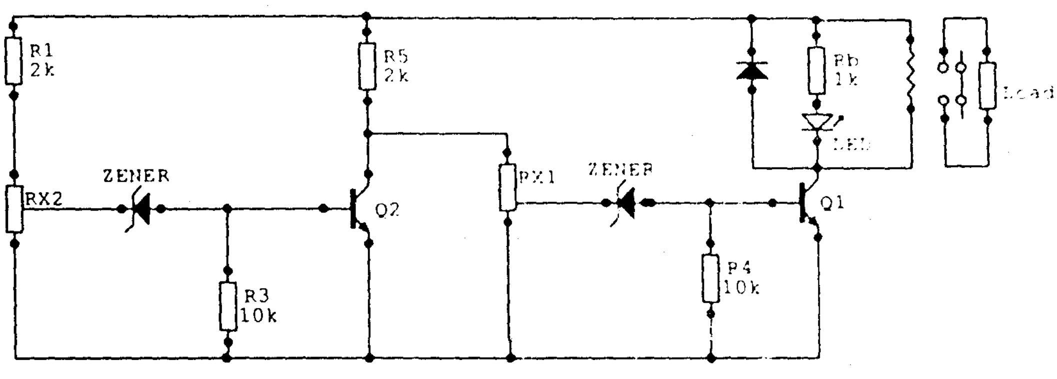


Figure 3.6: Basic transistor switch

3.2 Design and Calculation.

3.2.1 Rectifier and Filter Circuit Components

The desired result of rectification is direct current, but the output current of the rectifier circuit described, obviously contains a considerable amount of alternating components along with the D.C components as shown in Figure 3.3 This A.C component constitutes the ripple. As a measure of the effectiveness of rectification we define the **ripple factor r**

a. Where $r = \frac{Vl\ (a.c)}{Vl\ (d.c)} = \frac{Vr\ (r.m.s)}{Vl\ (d.c)}$

And

$$Vl = Vlm\ \{\frac{2}{\pi} - \frac{4}{3\pi}Cos2wt - \frac{4}{15\pi}Cos\ 4wt - \frac{4}{3\pi}Cos6wt - \qquad [1]$$

(The Fourier series for rectifier stage)

given that Vlm = Maximum value o load voltage

Vl (dc)= Average value of load voltage

Vl (ac) = Average value of a.c volatege

As shown in the Fourier series

$$Vl\ (d.c) = \frac{2}{\Pi}Vlm = 0.636\ Vlm$$

Also $V_{l1} = \dfrac{4V_{lm},}{\sqrt{2}\;3\pi}$, $V_{l2} = \dfrac{4V_{lm}}{\sqrt{2.15}\;\pi}$

Hence $V_l\,(a.c) = \sqrt{\;V_{l1}^2 + V_{l2}^2}$

$$V_l\,(a.c) = \sqrt{\frac{4V_{lm}}{\sqrt{2.3}\,\pi} + \frac{4V_{lm}}{\sqrt{2.15}\,\pi}}$$

$V_l(a.c) = 0.305\ V_{lm}$

$$r = \frac{V_l(a.c)}{V_l(d.c)} = \frac{V_r(r.m.s)}{V_l(d.c)} = \frac{0.305\ V_{lm}}{0.636\ V_{lm}} = 0.482$$

b. Efficiency (%η)

Efficiency of the full wave bridge rectifier is given as

$$\%\eta = \frac{8.12}{1 + {}^{2rd}\!/_{Rl}}$$

But rd << Rl

$$>> 1 + \frac{2rd}{Rl} \cong 1$$

$>> \%\ \eta = 81.2\ \%$

Hence, the efficiency of the rectifier is 81.2%

c. Peak Inverse Voltage (PIV)

The peak inverse voltage rating of each of the four diodes is equal to Vsm. The entire voltage across the secondary winding of the transformer

PIVmn = Vsm [1]

d. Capacitance

The minimum capacitance required to keep the ripple low and ensures good regulation is obtained from

$$Vdc = Vm - \frac{Idc}{2Fc}$$

$$C = \frac{Idc}{2F(Vm - Vdc)}$$

F is taken to be the main frequency. That is 50Hz.

V (dc)	=	Volatge across the load
Vm	=	Voltage across secondary winding of the transformer
I (dc)	=	Load current
F	=	Frequency
C	=	Capacitance

$$Idc = \frac{2\,Im}{\pi}$$

$$Im = \sqrt{2} \times Insm$$

When $Insm = 500 \times 10^{-3} A$

$$Idc = \frac{2 \times \sqrt{2} \times 500 \times 10^{-3}}{\pi}$$

$$= 0.4502 \quad A$$

$$Vm = Vsm\,\sqrt{2}\ -\ \sqrt{2}$$

$$Vm = 16.97 - \sqrt{2}$$

$$Vm = 15.56v$$

$$Vdc = \frac{81.2}{100} \times 15.56$$

$$Vdc = 12.63$$

$$C = \frac{0.4502}{2 \times 50(15.56 - 12.63))}$$

$$C = 1.536\ \mu F$$

However a 3200 μF (12v) capacitor is used so the ripple effect would be negligible.

3.2.2 Power Indicator Circuit

The power indication circuit consists of a limiting resistor and a light emitting diode as shown in Figure 3.7

A 2 kΩ resistor is used for resistance to limit current supply to the light emitting diode.

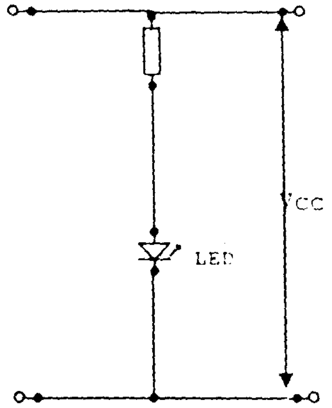


Fig 3.7 I Indicator network

3.2.2.1 Light emitting diode.

Light emitting diode as the name implies, is a forward biased P-N (as shown in fig 3.8) junction which emits visible light when energized.

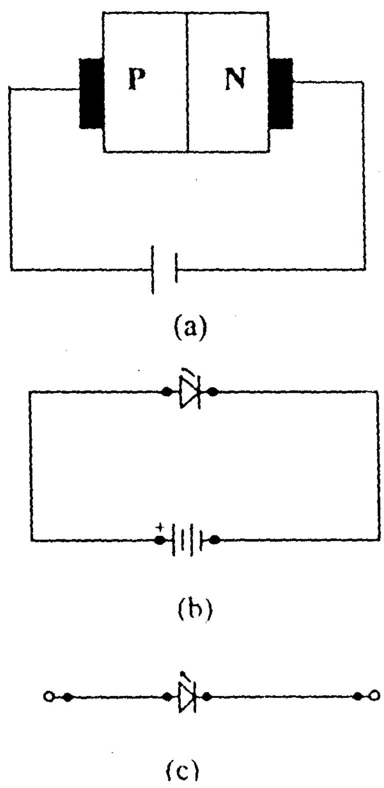


Figure 3.8: Light emitting diode

Charge carrier recombination takes place when electron from the N-side cross the junction and recombine with the holes on the P-side.

Now electrons are in higher conduction band on the N-side whereas holes are in the lower valence band on the P-side. During recombination some of this energy difference is given up in the form of heat and light up that is photon. In silicon and germanium junctions, the greater percentage of this energy is given up in the form of heat so that the amount emitted as light is insignificant but in the (GaP) Gallium-Phosphide and gallium-arsenic-phosphide (GaAsP), a greater percentage of energy released from recombination is given out in the form of light energy. If the semiconductor material is translucent, light is emitted and the junction becomes a light source. That is a light emitting diode (LED). The colour of the emitted light depends on the type of material used is given below:

1) GaAs – infrared radiation (invisible)
2) GaP - red or green light.
3) GaAsP – red or yellow (amber) light

LEDS emit no light when rrse biased operating. LEDS in reverse direction will quickly destroy them.

3.2.3 Regulation and Switching Circuit

This circuit is made up of a rheostat level diode, transistor connected to form a derivative circuit of the transistor shunt voltage regulator as shown in Figure 3.9.

It employs the transistor in shunt configuration as shown in Figure . Since path AB is parallel across Vl we have from Kirchoff's voltage law (KVL).

Vl –Vz – Vx = 0

Vx = Vl – Vz

Vz = Zener Voltage

Since Vz is fixed any decrease or increase in Vl (voltage across the load) will have a corresponding effect on Vbc. Suppose Vl decreases then as seen from the above relation Vbc also decreases. As a result b decreases. Hence Ic = BIB decreases thereby decreasing I and hence Vr = Ir.

The transistor shunt voltage regulator circuit behaves this way for normal operations only.

[1]

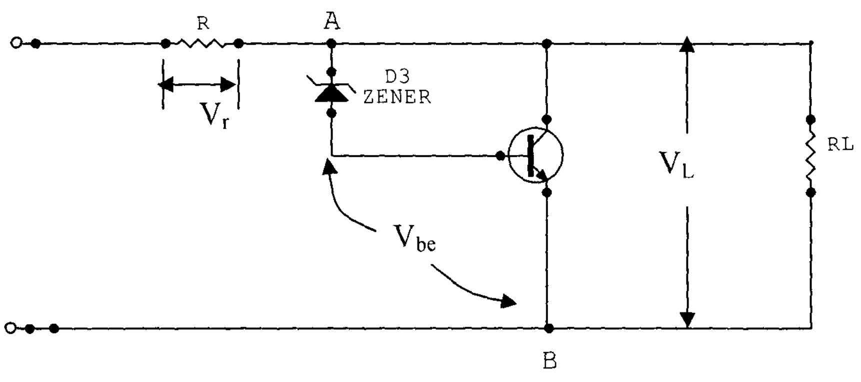


Fig 3.9: Shunt Voltage regulator

Over Voltage Condition

The transistor shunt voltage regulator circuit behaves like a transistor switch. See Figure

$Vr1 \geq 6.3$ volts

$Vz = 5.6$ volts$Vm = Vr1 - Vz \quad \Rightarrow \quad Vm \geq 0.7$ volts

VR1 = Voltage across the rheostat

Vz = Zener diode

Hence during over voltage condition transistor (2), Q2 comes on and brings point D to ground (Figure 6). Therefore the relay contact stays open.

For under voltage conditions.

$Vr2 < 6.3$ v

$Vz = 3.6$ v

$Vm < 0.7$ v

Hence $Vm - Vx < 0$

$\Rightarrow Ib = 0, \quad Ic = hfcIb = 0$

Vin = input voltage to the transistor

Ic = collector current

hFE = forward current gain

This implies that the transistor switch will not come on. Hence, relay contacts will open.

3.2.3.1 Zener Diode.

A zener diode is a special diode that operates I the reverse bias. It is a reverse-biased heavily doped Silicon or Germanium P-N junction, when operated. In the breakdown region current is limited by both external resistance and due to power dissipation of the diode silicon is preferred to Germanium because of its higher temperature and current capacity. At voltages less than Vz (the Zener voltage). Zener effect predominates while at voltage above Vz avalanche condition is predominant. Strictly speaking, when the Zener diode operates the first condition it is called Zener diodes and in the second condition called an Avalanche diode, but it is called a Zener diode even in both conditions as a general practice. In this project, the Zener diode is used as a voltage sub tractor and operates in the Avalanche mode.

3.2.3.2 Rheostat Value Setting Rx

At 220 volts the voltage across the transformaer secondary Vsm 11 volts.

$\Rightarrow \quad Vsm = 11$ v

$Vm = \sqrt{2}\, Vsm - \sqrt{2}$

$Vm = 14.14$ volts

For under voltage setting for Rx

Below 180 v $\Rightarrow$ Vsm = 9 v

Rx + Rz = 20,000 Ω

$$Vm = \sqrt{2}\ Vsm - \sqrt{2}$$

Vm = 11.31 v

Vrx = 6.3 v (is taken)

$$Vr = \frac{Rx}{Rx + Rz} Vsm \Rightarrow 6.3\ v = \frac{Rx}{Rx + Rz} 11.31$$

$$6.3\ \{Rz + Rx\} = 11.31\ Rx$$

6.3Rz + 6.3Rx = 11.31Rx

6.3R = 5.01Rx

$$\frac{Rz}{Rx} = \frac{5.01}{6.30} = 0.8$$

Rz = 0.8Rx

$\Rightarrow$ R1 + 0.8Rx = 20,000

1.8Rx = 20,000 $\Rightarrow$ Rx = 11.11 kΩ

where Vsm = voltage across the transformer secondary

Over voltage setting of Rx

At 260 v Vsm = 13 v

$Vn = \sqrt{2}\, Vsm - \sqrt{2}$

$Vm = \sqrt{2}\, 13 - \sqrt{2}$

Vm = 16.97 v

$$VRx2 = \frac{Rx}{Rx + Rz} 16.97$$

6.3Rz + 6.3Rx = 16.97Rx

6.3Rz = 10.67Rx

$$\frac{Rz}{Rx} = \frac{10.67}{6.3} = 1.69$$

Rz = 1.69Rx

R1 + 1.69R1 = 20,000

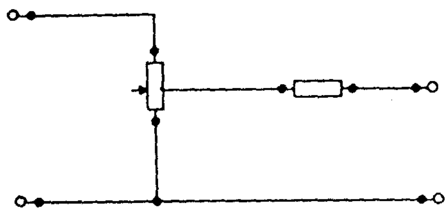
2.69R1= 20,000s

R1 = 7.43k Ω

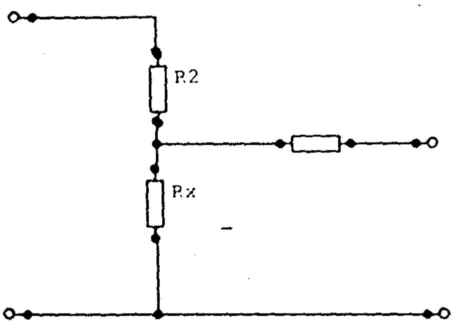
Hence for Rz

Under voltage Rz = 8.8k Ω

Over voltage Rz = 12.34k Ω



(a)



(b)

Fig 3.10: Rheostat analysis diagram

3.2.4 Timer Circuit

The timer circuit is realized from a monostable using 555 timer IC. The operation is such that when timer is triggered, capacitor C4 starts charging through resistor R9 until its voltage reaches.⅔ of the supply voltage then a regenerative action takes place and the capacitor starts to discharge until its voltage falls back to ⅓ of the supply voltage.

The time during which this operation takes place determines the required delay period for the transistor switch to supply the relay.

The G and R7 network provides the required threshold characteristics for triggering the monostable circuit Cz changes through resistor R7 when the function between Cz and R7 is shorted to the ground. Capacitor is rapidly discharged.

A current of 70 μ A is assumed to flow through R7 and C2 network, but only 2% of this current is required to trigger the time.

Hence, voltage drop across R7 = VR7

$$R7 = \frac{Vcc - \frac{1}{3}Vcc}{70 \times 10^{-6}} = \frac{12 - 4}{70 \times 10^{-6}}$$

R7 = 114.29 kΩ, a 100kΩ is used as a standard.

The waiting time (T) to be determined theoretically from the values of resistor R9 and capacitor C4 through the relation T = 1.1R9C4,

C4 = 100 μ F, R9 = 100kΩ

$T = 1.1 \times 100 \times 10^{3} \times 100 \times 10^{-6}$

T = 11 seconds

CHAPTER FOUR

Construction and Testing.

The power supply, the timer, and the switching stages were simulated on computer with the circuit maker programme and then tested separately on a bread board and each stage worked to satisfaction.

The whole circuit was connected together then simulated on the computer and also tested on the bread board and confirmed to be working as desired.

Each stage is then transferred to the vero board and confirmed to be functioning as designed to.

4.1 Test.

This test aims at determining the voltage conditions (levels) at which the appliance will either connect to power supply (ON) circuit off from power supply (OFF).

4.1.1 Procedure

The apparatus for performing the test are 240/120 step-down transformer, wall switch (to act as a circuit breaker), insulated flat nose screw drivers, a battery charger with indicator, voltmeter.

Due to difficulty in securing an auto transformer to set the variable resistors for both the minimum voltage and maximum voltage cut-out operation a little ingenuity in exploiting the main working operations of the circuit is applied for the testing.

The variable resistor acts as the main voltage level sensor that activates the transistor switch for both on or off operation.

IN real life the value of the variable resistance is preset for the under voltage are over-voltage, switching "ON" and switching "OFF" actions of the transistors (with the use of an auto transformer) but by varying the value of each resistance. The voltage supply to the transistor changes and the circuit interprets this as a drop or rise in supply voltage hence it operates the normally open relay contacts and either maintains or switches off power to the appliance is protecting, the battery change in this case on satisfying the circuit connection, the supply voltage (210 volts a.c). The value of over voltage switch (transistor) rheostat resistance is reduced to simulate an over voltage conditions and the value of the under voltage rheostat is also adjusted after the over voltage rheostat resistance has been restored (to its original approximate value) to simulate the under voltage condition.

The circuit is further tested with a 240/120 v step down transformer, to further confirm the under voltage condition.

For the power interruption condition, the delay time was observed for consistency.

4.2 Summary of Operation.

The responses of the voltage switch to the simulated voltage conditions and is classified into the following conditions

i) Under voltage conditions

ii) Normal voltage conditions

iii) Over voltage conditions

iv) Power interruptions

4.2.1 Under Voltage Condition (0 – 180 v)

From the test, observation shows that at voltage levels from 120 – 180 volts. The relay switch is in actuated. The normally open contacts remain open due to the low voltage and red LED (load). Indicator comes on to indicate that there is power supply to the circuit ; and consequently also the indicator lights of the battery changer remains off indicating that there is no supply of the load.

4.2.2 Normal Voltage Condition (180 - 240 v)

Where the voltage supply is taken back to normal mains supply (190 – 210 v) the circuit operates normally with the green power on LED indicator coming on first and after the delay of 10 seconds the red LED (load). Indicator lights come on indicating that the relay is now actuated and simultaneously the battery charger indicator lights come on to show normal operation.

4.2.3 Over Voltage Condition (260 v -)

The over voltage condition is simulated, the transistor Q2 goes high and the red LED light indication for the load goes off as well as the indicating lights of the charger showing there is non supply to the transistor Q1 which is disconnected from power supply.

4.2.4 Power Interruption.

On power down conditions, the whole circuit shuts down and the relay contacts now open, on restoration of power the green LED lights on and after the delay time (11 seconds in this project) the red indicating light come on indicating that the relay is actuated and its contacts now closed hence the load is supplied as the battery charger indicator lights are on.

CHAPTER FIVE

Conclusion and Recommendation

5.1 Result and Conclusion

The result from the testing of the project shows that the device will compete well with other protective devices.

i) It detects voltage fluctuations.

ii) It cuts off supply to protected appliance at the preset abnormal voltage levels.

iii) It automatically restores power to the appliance when the situation becomes normal.

iv) In the event of power failure it delays the turn-on of the appliance protected until the predetermined interval of time (11 seconds in this project). It performs the delay operation whether switched intentionally or during power interruption.

v) It is cheap and affordable by domestic users and small business owners.

5.2 Recommendation.

i) The device is suitable for electrical devices/appliances with input rating of not more than 240v/10A A.C; therefore for efficient operation equipment to be protected by the project copy should fall below this range.

ii) The user of the device should be patient to wait for a short time for the protected appliance to come on.

iii) If power is switched off intentionally a period of at least four (4) seconds should elapse before switching on again.

5.3 Suggestion

i) The efficiency of the device can be improved upon by increasing the output of the device to be able supply loads with input current by replacing the current relay with a higher rating.

ii) The principle of operation of this project could be implemented for $\{3-\theta\}$ three phase loads.

5.4 Conclusion

This project has shown the possibility of designing and constructing a low cost device which can be used to project electrical/electronic appliances against abnormal voltage conditions effectively.

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