DESIGN AND CONSTRUCTION OF A DIGITAL AUTOMATIC THREE- PHASE CHANGER

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FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA.

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IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR DEGREE (B. ENG) IN ELECTRICAL / COMPUTER ENGINEERING

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DECLARATION

I hereby declare that this thesis presented for the award of degree (B. ENG) in the department of Electrical / Computer Engineering, Federal University of Technology, Minna, has not been presented as a whole thesis elsewhere and all information from all other published materials used are duly acknowledged.

RTasha .... | 03/12/2004 ....

Tolulope Ruth Asha | **Date**

CETIFICATION

I certify that this thesis presened was fully carried out by Tolulope Ruth Asha, of the department of Electrical / Computer Engineering, Federal University of Technology, under the supervision of Engr. T. Asula.

....	15. 12. 2004 ....
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(Supervisor)	
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....	....
External Examiner	**Date**

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To you: Oladipupo, you are indeed all I ever wanted.

DEDICATION

This thesis is dedicated to my mother, Late Mrs. Olayinka Akorede Asha, who had always desired me to be an Engineer. It's a dream come true but in your absence.

ABSTRACT

This project presents the design and construction of digital automatic three- phase changer. The whole system is designed around some logic Ics which feed the input of a driver to open or close the relay contacts that are connected to the phases of NEPA supply tapped from the primary of the transformer in order to select the highest or full load voltage supply among the three phases.

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CHAPTER ONE

GENERAL INTRODUCTION

1.1 INTRODUCTION

The availability of adequate power supplies of energy is a matter of great concern throughout the world. Energy is linked to food production, industrial output, wealth, health and lifestyle

The overhead construction of an A.C distribution was considered satisfactory but in the course of only few years however the installation of overhead wires for electric distribution line led to such congestion. And another force behind the shaping of distribution circuit design of equipment is system reliability. This force probably more than other has influenced the design of equipment ever since the beginning of utility industry.

The major causes of failure on overhead distribution circuit are wind, trees, lighting and equipment failure. At a time when fuel shortage are occurring, prices are escalating and environment constraints on energy conversion are increasing, improved efficiency of utilization is the best short-term alternative for increasing that adequate supply of energy to remain available. Therefore in this project, the design and construction of a device named digital automatic three- phase changer, which is used to supply a continuous full potential difference at output, provided there is at least one full phase among the three phases.

This device is operating the appropriate input (phase) through the sensor (comparator). The decoder processes these selected inputs. The output of the decoder feeds the base of the switching transistor to activate the relay, in order to act as a driver, which bases are connected to the logical circuit in order to energize the relay which close and open the contact depending on the state of input base voltage. The contact of the relay is connected to the phase of the NEPA supply.

1.2 LITERATURE REVIEW

Electricity was discovered by MICHEAL FARADAY (1791 – 1867). Economic scale and relative continuity all combined to promote the growth of central station electric power service, which was indeed the brainchild of THOMAS EDISON. Voltage drop and resistance losses on the low voltage D.c distribution circuit were the first limiting factor encountered. The problem of voltage regulation became more pronounced when the generating station is also distanced from the consumers.

The voltage regulator came into use soon after Thomas Edison's break through (19TH century). Its usefulness was a result of variation in transmission voltage. The earliest attempt at obtaining an automatic voltage employed a motorized system controlled by a control circuit to exchange the taps on the secondary of an autotransformer so as to step-up when the voltage input is low, or to step-down when the input voltage is high. Some of the short disadvantages are that it is bulky, costly and the mechanical part easily wears out resulting in proper contacts between the charger and the taps of the transformer.

Another approach was the resonant circuit voltage regulator. This type of the AVR (Automatic Voltage Regulator) involves few components, inductance of the transformer coupled with a parallel inductance and the capacitance-resonant. When the line voltage falls below the rated values less current is drawn by the inductance and parallel circuit combination becomes capacitive. The capacitive current drawn through the transformer raised the output voltage. If line voltage is raised above the rated value the parallel circuit combination becomes less capacitive and the output voltage falls below the line value. The disadvantage of this approach is that it is bulky, heavy and frequency dependent.

The present technological dispensation has changed voltage stabilization technique greatly. This came with another approach known as regulated D.C inversion approach. This uses the principle of switch- mode power supplies. The regulated D.C output from the power supply is inverted using transformer. The output of the system is a square wave A.C voltage, which could be filtered to obtain a pure sinusoid. This method produces good regulation. The system is not heavy but expensive and complex that the other system.

Phase controlled AVR is one of the attempt toward realizing a good AVR (automatic voltage regulator). In this system the load is connected in series with the voltage-controlling device, which is usually, a silicon controlled rectifier (SCR) and transistor. Voltage control is achieved by triggering the SCR at a voltage control circuit in such a way that the voltage across the load connected to output terminals is regulated to the desired value. The method is very fast in response to voltage fluctuation at input. The system is not heavy and is not expensive; the disadvantage of this method is that the output waveform is distorted.

These entire automatic voltage regulators have a common limit of raising the input voltage at normal undesired value when a certain under-voltage occurs at NEPA supply voltage due mainly to overloading.

This approach uses the control circuit to dictate to the three relays connected to each of the three lines of NEPA supply to switch on the contact to the higher voltage supply. The beauty of this approach is that, it is relatively cheaper, lightweight, size reduced and good response. The varieties of ways of coming up with a voltage sensing device and an automatic control circuit have given different kind of voltage supply regulations.

1.3 PROJECT OBJECTIVE

The objective of this approach is to improve the availability and the efficiency of electric energy in such a way that designed device selects and delivers a normal output voltage continuously regardless of any low voltage state of the phase provided there is at least a normal potential among the three phases.

1.4 PROJECT LAYOUT

This project is written in four chapters as follows:

The general introduction which includes introduction, literature review, project objective and layout is discussed in chapter one while chapter two deals with the theoretical background to analyze clearly the elements constituting the project and also the design procedure and calculations. Chapter four deals with the construction work, testing of result, and; lastly conclusion and recommendation are discussed in chapter four.

CHAPTER TWO

THEORETICAL BACKGROUND AND SYSTEM DESIGN

2.1 POWER SUPPLY

The block diagram shown below is a typical D.C power supply system and incorporates the following units: transformer, rectifier, filter and regulator.

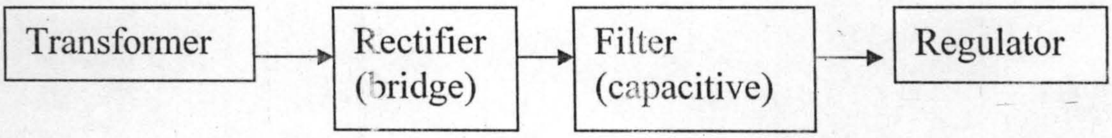

Fig. 2.1 Block Diagram of Power Supply Unit

2.1.1 TRANSFORMATION

A transformer is an electric device, which makes use of electromagnetic induction to transfer electrical energy from one coil to another. Thus it is capable of changing an alternating voltage from one value to another. In practice a transformer always has a finite winding which cause the efficiency to be less than 100% for a sinusoidal input voltage, the flux ø varies alternately that is $\phi = \phi$ max sin wt and the instantaneous voltage in primary is due to FARADAY'S LAW:

$$E = Et = \frac{-d\phi N_1}{dt} = 2 \times \pi f \times N_1 \phi_{MAX} \cos(\omega t)$$

Where $\omega = 2\pi$, Thus

$$E_{tMAX} = 2 \times \pi f \times N1 \times \phi_{MAX} \text{Cos}(\omega t)$$ or the rms value of Et is

$$E\,rms = \frac{2 \times 3.14 \times f \times N_1 \phi_{MAX}}{\sqrt{2}} = 4.44 \times f N_1 \phi_{MAX}$$

$\sqrt{2}$

Since the flux is the same for the primary and the secondary.

The secondary voltage and current can be derived from:

$$\frac{V_2}{V_1} = \frac{E_2}{E_1} = \frac{4.44 \times F \times N_2 \times \phi_{MAX}}{4.44 \times F \times N_1 \times \phi_{MAX}} = \frac{N_2}{N_1} \quad (\phi_{2\,MAX} = \phi_{1MAX})$$

$$\frac{V_2}{V_1} = \frac{N_2}{N_1} \quad \text{.......... 2.1}$$

As it flows, it develops magnetic effect, which oppose the flux.

By LEN'S LAW with magneto motive force (mmf) of Is Ns ampere-turn to balance this, an additional primary current flows to produce the primary ampere-turns

$N_p I_p = N_s I_s$ or

$$\frac{I_P}{I_S} = \frac{N_S}{N_P} \quad \text{.......... 2.2}$$

Combining 2.1 and 2.2 gives

$$\frac{V_2}{V_1} = \frac{N_2}{N_1} = \frac{I_1}{I_2} \quad \text{.......... 2.3}$$

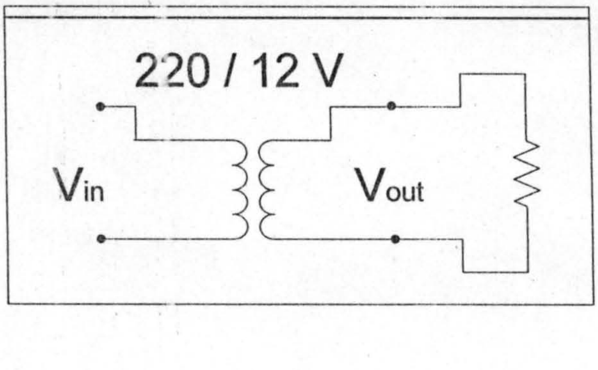

Fig.2.2 Transformation Circuit

2.1.2 RECTIFICATION

Rectification converts A.C to D.C through the use of rectifier. A rectifier is an electronic device, which offers a low resistance to the flow of current in one direction (known as forward biased) and high resistance to flow current in the reverse direction (known as reverse biased)

Rectifier may be used to carry out half or full wave rectification depending on the application. In this project we shall be concerned only with full wave bridge rectifier, which in essence allows the flow of D.C current in the output, throughout the alternating cycles of the input signal. A common type of bridge rectifier is the use of four discrete diodes arranged in bridge network.

They are connected as shown in figure 2.3a

Diode D1 and D2 conduct on alternation that is illustrated in figure 2.1.2 while D2 and D4 conduct on the negative half cycle, alternation B. Both conducting paths deliver current to the load in the same direction.

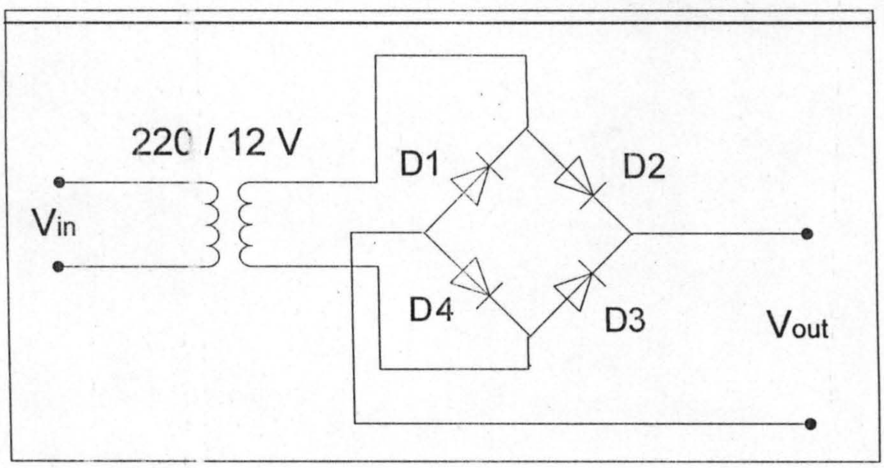

Fig. 2.3a full bridge rectifier

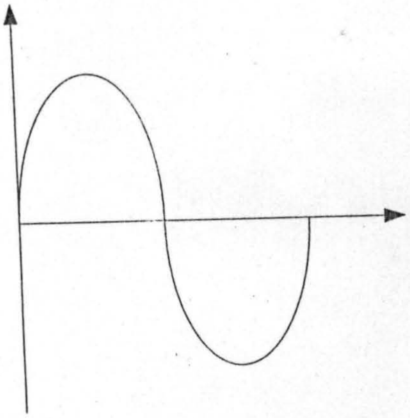

Fig. 2.3b input waveform for full bridge rectifier

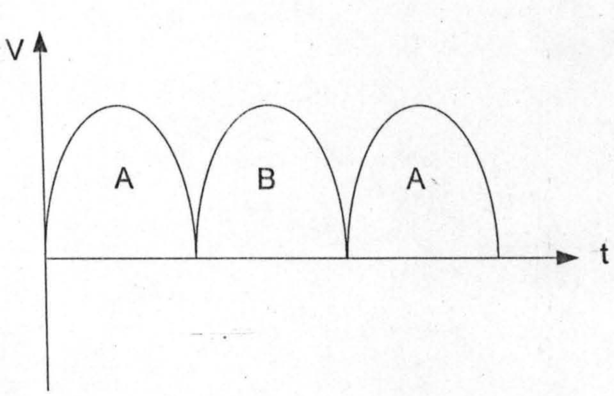

Fig. 2.3c output waveform showing the conduction

2.1.3 FILTERING

A filter is required to smooth the pulsing D.C the output of rectifier. Various types of filters are built using a combination inductor and capacitor or each single one in combination with resistor. However a Single capacitor in parallel with the output from rectifier performs the required filtering action where the capacitor stores energy during the conduction period and deliver it to the load during the non-conducting period, hence the time of flow through the load is prolonged.

The filter capacitor must then be large enough to store sufficient amount of energy to provide a steady supply of current to the load, otherwise the output will drop as the load demands more up to date.

The approximated output waveform can be represented by figure below

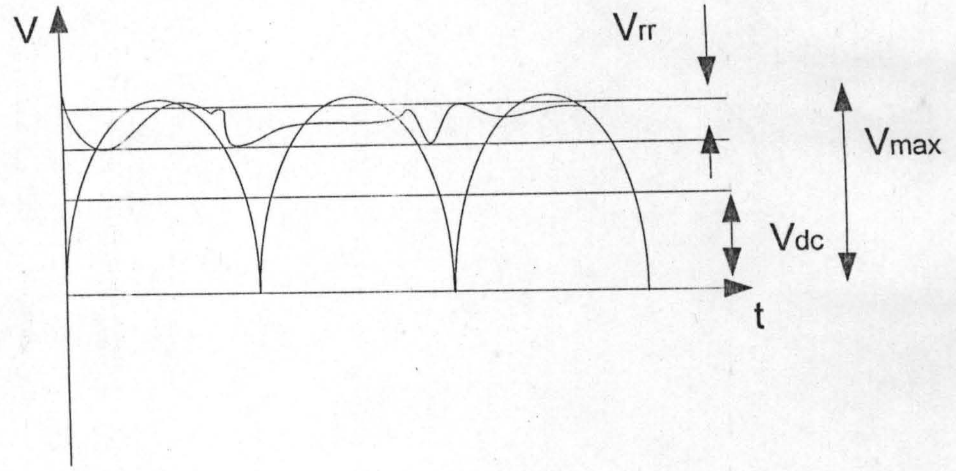

Fig. 2.4 output of the filter

2.1.4 REGULATOR

Since the output voltage of an unregulated D.C supply will fall considerably when the load current increases. In order to have a D.C output, which will be independent of the load current drawn, we employ the use of the regulator. Although many types of regulators are available, a three terminals voltage regulator IC is preferred. This is because of its simplicity in mounting it easily and self-protection features it feedback. Further more an error amplifier, control element, current limit or thermal limit voltage reference and sampling are all of which are contained in a single IC package.

2.2 SENSOR

2.2.1 COMPARATOR

Comparator is a device, which is used to sense when varying signal reaches some threshold value. It is a circuit, which compares the signal level or a voltage level. The circuit is shown in figure 2.2.1 below like that of the unity follower is the simplest form of comparator because it needs no additional external component.

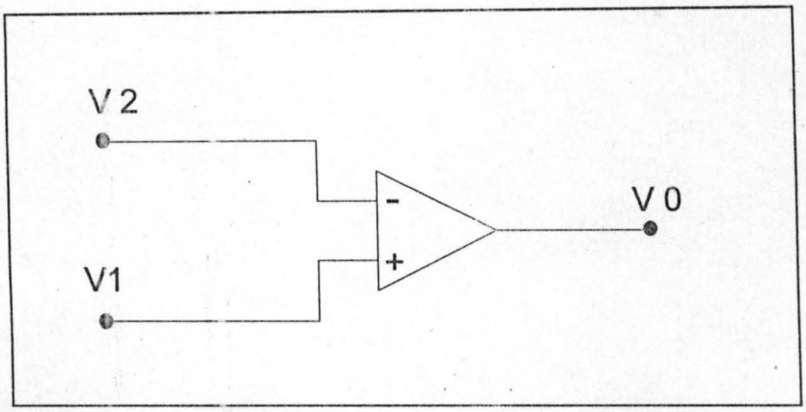

Fig. 2.5a comparator Circuit

V1 and V2 equal then V0 should ideally be zero. If V1 differs from V2 by small amount, V0 is large because of the amplifier's high gain. An operator amplifier can perform the comparator function described above quite easily. The major function of the comparator with logic levels of the circuit employed some non-linear operation amplifier (no feedback), which switches between +Vsat and –Vsat. This suggests square wave output and digital application because of the fast response time and the output compatible with digital component circuit elements (ICS).

The simple way of using an operational amplifier to perform the function of the comparator is to apply the signal directly to one of the input terminals and the reference voltage to the other as illustrated in figure below

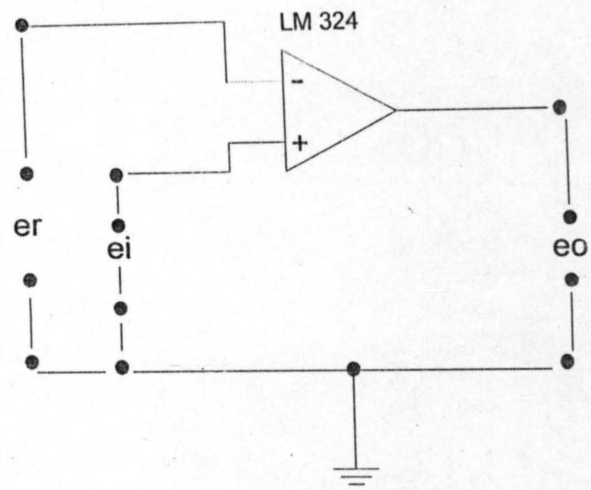

Fig. 2.5b Differential Amplifier

2.2.2 ZENER DIODE

When large variations in current are likely to occur, the accompanying voltages are often quite unacceptable. It is desirable that the output voltage remains largely independent of the current, which is drawn from equipment. In such circumstances the output voltage needs to be stabilized therefore a Zener diode has always its nominal specified voltage across it. It will happen once breakdown has occurred. This characteristic means that this type of diode can be used for the following applications.

- Over voltage protection
- Limiter or Clipping circuit
- Voltage stabilizer, which is our concern

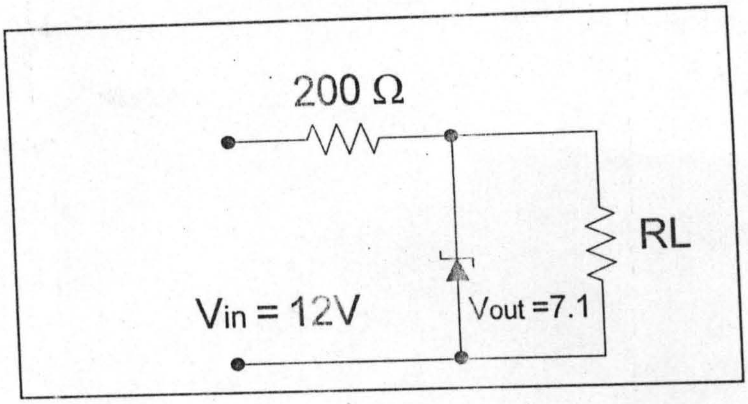

Fig. 2.6 Zener diode circuit

V_{out} will always be Zener voltage
$V_Z = V_{OUT}$
$I_t = I_Z + I_L$
$I_L = V_{OUT} / R_L$
$I_{Z\,MAX} = P_{Z\,MAX} / V_Z$
$R_S = V_{S\,MAX} / I_{Z\,MAX}$

2.3 DECODER

The decoder is the control part of the system. Its function is to select the appropriate input signal at a time and perform the desired operation using digital and switching system. Digital system is assemblages of interaction parts that are capable of storing, communicating, and processing information expressed in discrete form. Simple binary processing elements are known as gate and the mathematical technique used in solving logical problem is known as Boolean algebra.

2.3.1 LOGIC GATE AND CIRCUIT

The logic elements in instruments are the basic building blocks of the logic circuit, which control the flow of information through the system. For this reason the elements are referred to as logic gates are opened and closed by the combination or sequence of events occurring at their input. Logic gates have generally very short names such as AND, OR, NAND, EX-OR; but NAND and NOR gates are actually derivatives of three namely NOT, AND, and OR. Each logic gate gives specified type of output when a number of different inputs are fed into it.

2.3.2 THE LOGIC 'AND' GATE

The AND gate gives a logic 1 output if and only if all the inputs stand at their defined logic 1 state, otherwise gives logic 0 output

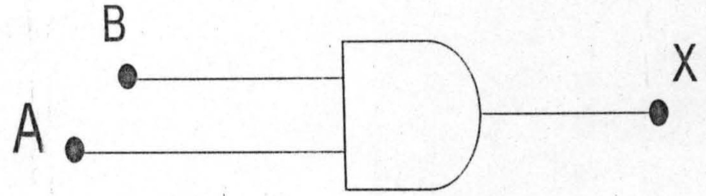

Fig 2.7 Symbol Representation

2.4 DRIVER

2.4.1 THE BIPOLAR TRANSISTOR AS SWITCH

A bipolar transistor can be used in such a way that its collector voltage swings between two extremes. With a perfect device, this is exactly equivalent to a conventional switch. To implement an NPN transistor as a switch, figures 2.8(a) and (b) below shows a typical example.

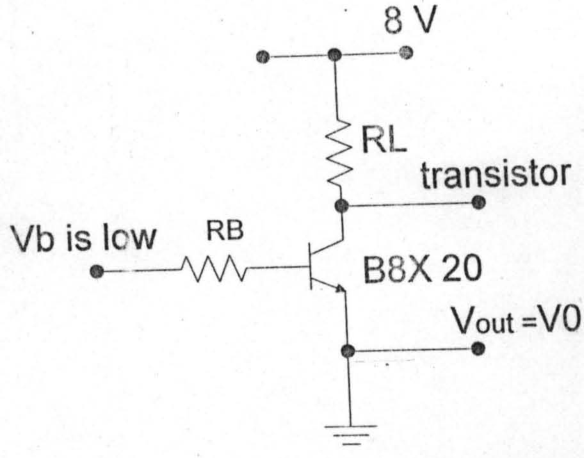

Fig 2.8a

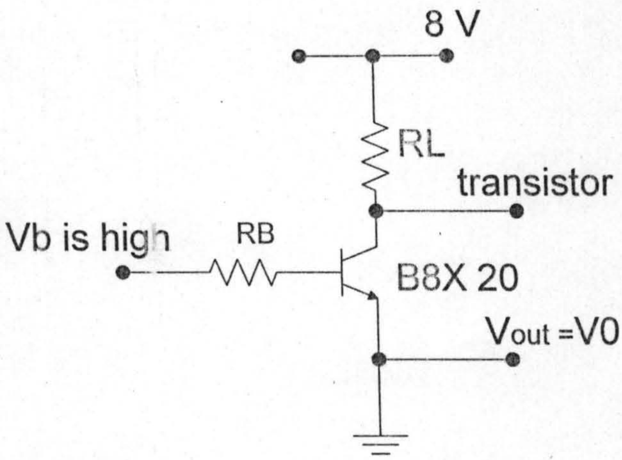

Fig 2.8b

In figure 2.8a, the base emitter junction is reversed biased by holding the base voltage at a suitable low voltage with respect to the emitter. This prevents the transistor from conducting, with the result that the output

voltage will rise to a value close to V_{cc}. If the transistor could switch off completely, then of course the output voltage would be exactly equal to Vcc. But this can only happen if the impedance between the collector and emitter is infinite. At impedance less than infinite a current will flow from supply through the load resistor and transistor to ground. With the saturation illustrated in figure (2.8a) the transistor is regarded as being OFF, but a small leakage current I_{CEO} will flow, causing a potential drop across the load resistance equal to I_{CEO} * R_L. V will give the output voltage $V_{OUT} = V_{CC}$ - $I_{CEO}R_L$. In figure 2.8b, the base- emitter junction is forward biased by holding the base voltage at a suitably high potential with respect to the emitter. The transistor will conduct heavily and will saturate at a maximum value of collector current I_{CMAX}. The output voltage can only be exactly equal to zero if the impedance between the collector and emitter becomes zero, which would cause the entire supply voltage to be dropped across the resistance R_L. If this happens then the collector current would be given by

$I_C = V_{CC} / R_L$

As the transistor is not a perfect switch, $I_{C\,(MAX)}$ will be less than V_{CC} / R_L and small voltage $V_{CE(MAX)}$ will remain across the collector – emitter of the transistor. This is illustrated in figure 2.8c below which gives the

V_{CE} / I_C characteristic for zero base current (I_B = 0) corresponding to a saturated transistor. The load line that is drawn for particular values of collector supply voltage and load is super imposed.

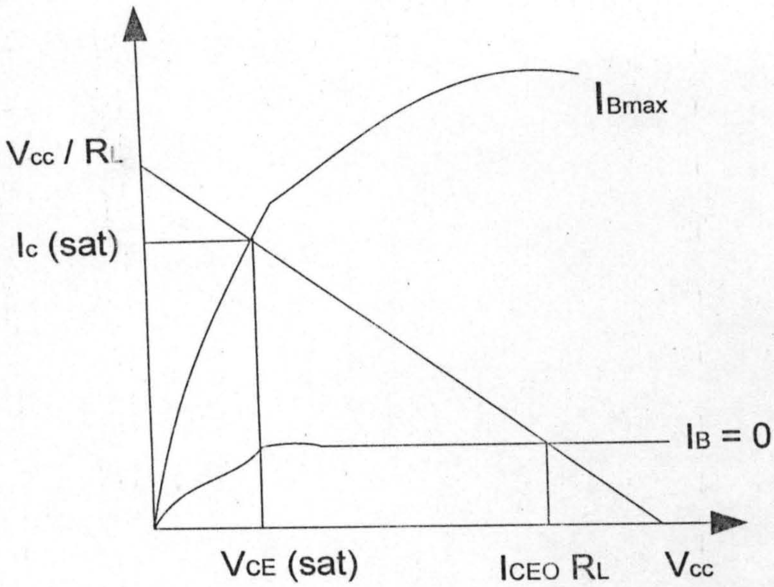

Fig . 2.8c

2.4.2 RELAY

The objective of many electromechanical systems is to control a simple output device. This may be as simple as a light, buzzer, electric motor or solenoid. A relay is an excellent method of isolating a logic device from a high voltage circuit. When the output of the logic circuit is high, the transistors are turned ON then the relay is activated. When activated the normally open (NO) contact of the relay closes as the armature clicks downward.

When the output goes low, the transistor stops conducting and the relay id deactivated. The armature springs upward to its normally closed (NC) position. The clamp (freewheeling) diodes across the relay coil prevent voltage spikes, which may be induced on the system .

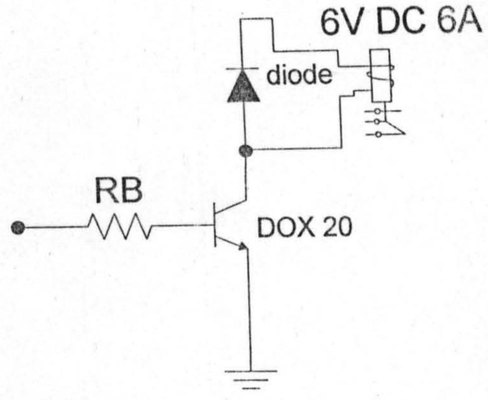

Fig. 2.8d Driver Circuit

2.50 STSTEM DESIGN PROCEDURE AND CALCULATION

As discussed in previous section, the design of the digital automatic three-phase changer involves basically the design of:

-A suitable power supply

-A sensor

-A digital logic circuit

-A driver

2.6 THE DESIGN OF THE POWER SUPPLY

2.6.1THE SELECTION OF THE POWER SUPPLY

While designing any power supply, it is necessary to determine the rating of the transformer. It can be done provided TUF (transformer utilization factor) is known. The value of TUF depends of the amount of power to be delivered to the load and the type of rectifier.

TUF = (D.C power delivered to the load) / (A.C power rating of the transformer secondary)

Ac rating of the transformer = (D.C power delivered to the load) / TUF

The table gives the total current of the component system:

COMPONENT	QUANTITY	CURRENT (mA)	TOTAL CURRENT (mA)	VOLTAGE
RELAY	3	8V / 100 = 80mA	240 mA	8V
LM 324 OP AMP	3	7V / 30 = 0.2 Ma	0.7 Ma	8V
CD 4069 CN	1	NEGLECTED		8V
MC 4073 B	1	NEGLECTED		8V
OTHERS		100Ma	100 Ma	8V
TOTAL ESTIMATE		340.7mA	340.7 mA	8V

Table 2.1 Showing The Total Current Of The Component System

The D.C power delivered to the load:

P_{AC} = 8V X 340.7Ma

= 8V X 0.340

= 2.72VA

For full wave rectifier, TUF = 0.693

Therefore, the A.C rating of the transformer = 0.72VA / 0.693 = 1.884VA

A step down transformer of 240V / 12V, 500 mA can work suitably in the supply unit.

2.6.2 THE SELECTION OF THE RECTIFIER

The rectifier used is full wave bridge rectifier that is used frequently for electronic circuit using D.C power supply. It requires four diodes with a transformer of a maximum voltage V_{SM}.

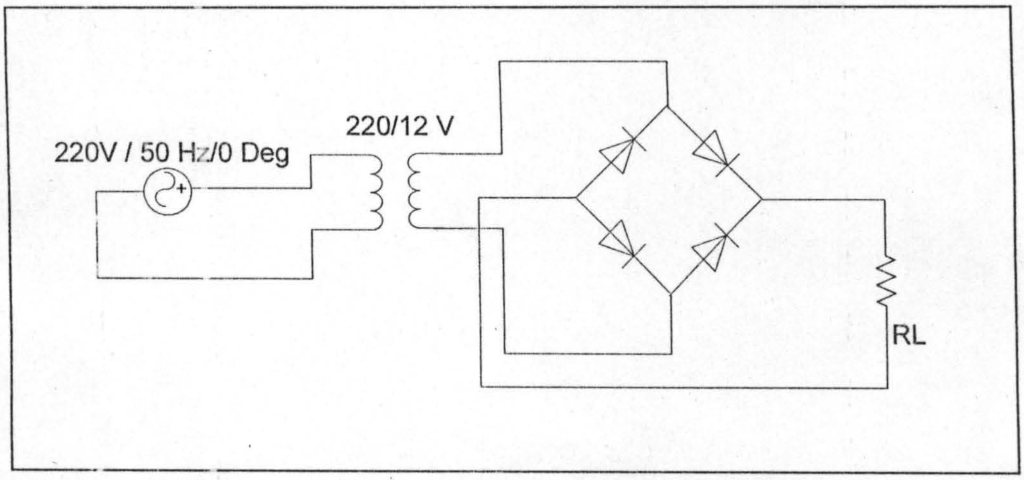

Fig. 2.9 Full Wave Bridge Rectifier Circuit

Average and rms values:

$$V_1 = \frac{V_{IM}}{\sqrt{2}} \quad \text{...Equation 1}$$

$=0.707V_{IM}$

$$V_{L(D.C)} = 2 \times \frac{V_{LM}}{\delta} \quad \text{...Equation 2}$$

$= 0.707\ V_{LM}$

$V_{L(A.C)} = \sqrt{V^2{}_L - V^2{}_{L(D.C)}}$ ....Equation 3

PEAK INVERSE VOLTAGE (PIV)

The peak inverse voltage rating of each of the four diodes is equal to V_{SM} (the entire voltage across the secondary)

Where V_S is the rms value of secondary

$VSM = \sqrt{2} \times VS$ ....Equation 4

$= \sqrt{2} \times 12V$

$= 16.97V$

With a safety factor of 1.5 then

$PIV = 19.79 \times 15V$

$= 25.45\ V$

RIPPLE FACTOR

$$\delta = \frac{V_{L(A.C)}}{V_{L(D.C)}} \quad \text{..Equation 5}$$

$V_{L(A.C)} = \sqrt{V2L - V2L\ (D.C)}$

$= \sqrt{V^2{}_{L1} + V^2{}_{L2}}$ ....Equation 6

$$V_{L1} = \frac{4V_{LM}}{\sqrt{2} \times 3 \times 3.14}$$ ....Equation 7

$$V_{L2} = \frac{4V_{LM}}{\sqrt{2} \times 15 \times 3.14}$$ Equation8

$$V_{L(A.C)} = \sqrt{\frac{(4 \times VLM)^2}{\sqrt{2} \times 3 \times 3.14} + \frac{(4 \times VLM)^2}{\sqrt{2} \times 15 \times 3.14}}$$

$= 0.305\ V_{LM}$

$$\delta = \frac{V_{L(A.C)}}{V_{L(D.C)}}$$

$$= \frac{0.305\ V_{LM}}{0.636\ V_{LM}}$$

$= 0.482$

The rectifier used in this circuit is IN 4001 with PIV of 100V

2.6.3 THE SELECTION OF FILTER

The main function of a filter circuit is to minimize the ripple content in the rectifier output. The output of various rectifiers circuit is pulsating. It has a D.C value and some A.C components called ripples therefore the output is not useful for driven electronic circuit/ devices. In fact, these circuits require steady D.C output that approaches the smoothness of a battery's output. A shunt capacitor filter shown in the figure below is used in this circuit

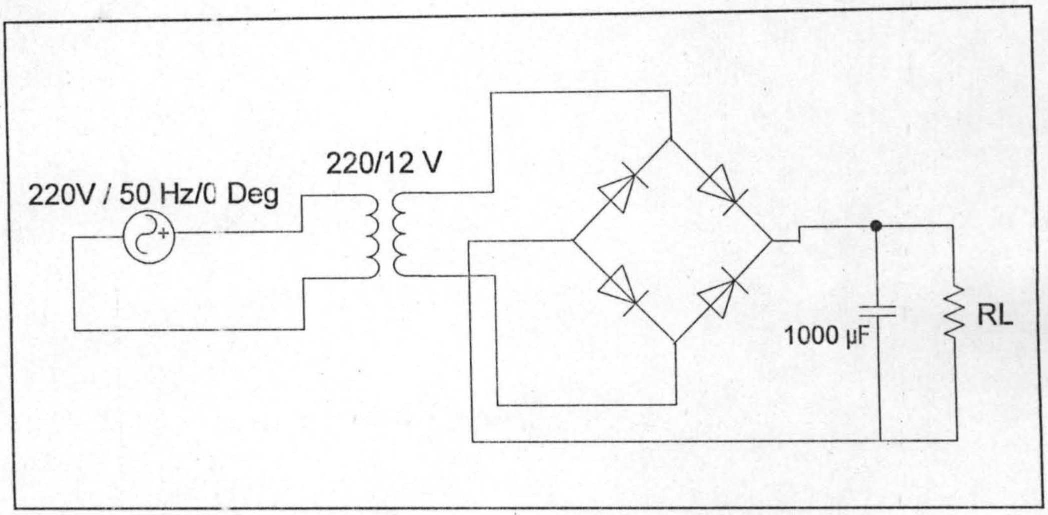

Fig.2.10 Output Of Shunt Capacitor Filter Circuit

$V_{r(p-p)}$ is the amount by which capacitor voltage falls during discharge period can be approximated into a straight line discharge, if we assume the discharge rate to remain constant at D.C level I_{dc} therefore charges lost dQ in time T_r is given as $I_{D.C} X T_r$

$$dQ = I_{d.c} \times T_r$$

$$V_{r(p-p)} = \frac{dQ}{C} = \frac{I_{d\cdot c} \times T_r}{C} = \frac{V_{d\cdot c}}{f_r \times R_L} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 9$$

Where $I_{d\cdot c} = \dfrac{V_{d\cdot c}}{RL}$

Triangle ripple has an arms value given by

$$V_r\,(rms) = \frac{V_{r\,(p\text{-}p)}}{2 \times \sqrt{2}} \qquad \text{.......10}$$

Substituting equation 9 into equation 10 gives

$$V_{r\,(rms)} = \frac{V_{d\text{-}c}}{2 \times \sqrt{3} \times fr \times C \times RL} \qquad \text{.......11}$$

Since fr equals double of the line input frequency for a full wave rectifier.

$$\delta = \frac{V_{r\,(p\text{-}p)}}{V_{d.c}} \qquad \text{.......12}$$

$$\delta = \frac{1}{2 \times \sqrt{2} \times F_r \times R_L \times C} \qquad \text{.......13}$$

$$\delta = \frac{I_{dc}}{4 \times \sqrt{3} \times F \times C \times V_{IP}} \qquad \text{.......14}$$

$$C = \frac{I_{d.c}}{4 \times \sqrt{3} \times F \times \delta \times V_{IP}} \qquad \text{.......15}$$

In the power supply used for the design circuit the secondary load current of the transformer is $I_L = 500mA$

Therefore $I_{d.c} = \frac{2 \times \sqrt{2} \times 500}{3.14}$

$= 450.15$ mA

Since $V_{IP} = 12$ V

$$C = \frac{450.15 \times 10^6}{4 \times \sqrt{3} \times 50 \times 0.482 \times 12}$$

$=2.2459 \times 10^{-4}$ F

$C = 2.2459 \times 10^{-4} \times 10^{6}$

$C = 224.59\mu F$

Since a bigger capacitor would tend to reduce the ripple magnitude, therefore a filter capacitance of 1000μF is used in this circuit

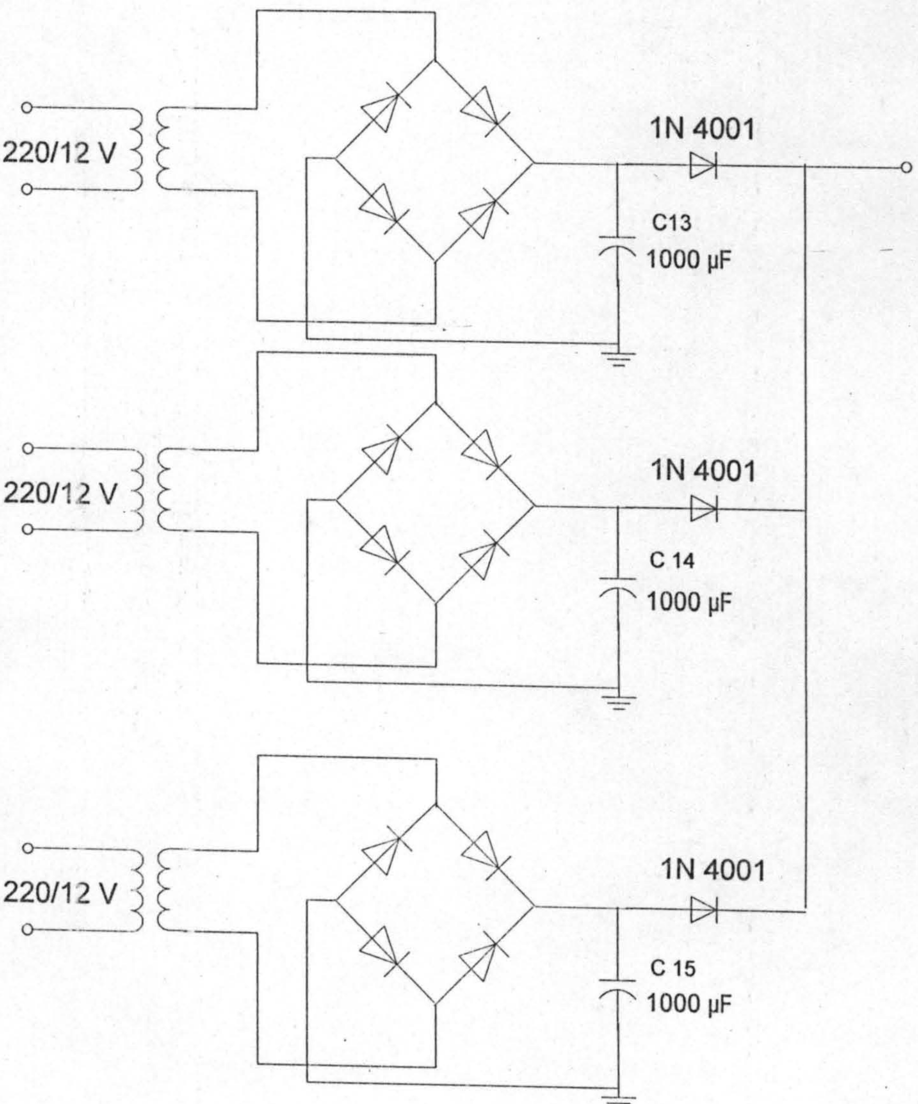

Fig2.11 Power Supply Unit

2.64 THE SELECTION OF THE VOLTAGE REGULATOR

A three terminals regulator (IC) MC7808 C is chosen to supply the electronic devices.

2.7 DESIGN OF THE SENSOR

2.7.1 THE SELECTION OF THE COMPARATOR

The comparator used in this project is IM 324. It consists of four op-amplifiers cascaded inside a single case only three of which are used. The device is ideally suitable for single supply application and it has an operating voltage as low as $\pm$ 1.5 V and the amplifier are compensated.

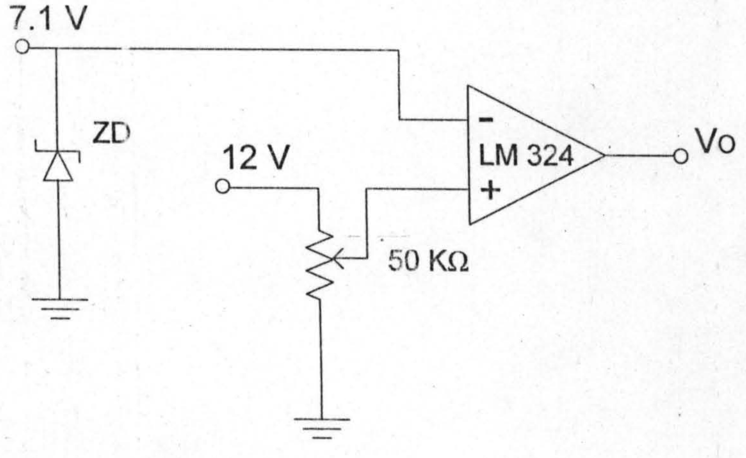

Fig.2 12 Comparator Circuit

V_{IN} = Input voltage, which is a voltage of the preset value of the variable resistor

V_Z = Stabilized output of the zener diode

V_O = Output voltage of the op- amplifier (comparator)

$$V_{IN} = V_{d.c} + \frac{V_{r(p-p)}}{2}$$

$$V_{d.c} = \frac{2 X V_{SM}}{3.14}$$

$$= \frac{2 X \sqrt{2} X 12}{3.14}$$

$$= 10.80V$$

$$V_{r(p-p)} = V_{r(rms)} \times 2 \times \sqrt{3}$$

$$V_{r(rms)} = \delta X V_{dc}$$

$$V_{r(rms)} = \delta X 10.8V$$

A capacitor of 1000μF is used in the circuit, which gives:

$$\delta = \frac{I_{d.c}}{4 X \sqrt{3} X F 1000 X 10^{-6} X 12}$$

$$= \frac{2 X \sqrt{2} X 500 X 10^{-3}}{3.14 X 4 X \sqrt{3} X 50 X 10^{-6} X 12 X 1000}$$

$$= 0.108$$

$$V_{r(rms)} = \delta X V_{d.c}$$

$$= 0.108 X 10.80V$$

$$= 1.16V$$

$$V_{r(p-p)} = V_{r(rms)} X 2 X \sqrt{3}$$

$$= 1.16V X 2 X \sqrt{3}$$

$$= 4.01V$$

$$V_{IP} = V_{d.c} + \frac{V_{r(p-p)}}{2}$$

$$V_{IP} = 10.80 + \frac{4.01}{2}$$

$$V_{IP} = 12.80\ V$$

The preset resistor value:

$$V_{IN} = \frac{R_x \times V_{IP}}{50K\Omega}$$

$$R_x = \frac{V_{IN}\ X\ 50\ K\Omega}{12.80V}$$

If $V_{IN} > V_Z$; then $V_0 > 0$

If $V_{IN} < V_Z$; then $V_0 = 0$

$V_Z = 7.1V$

This implies V_{IN} should be greater than 7.1V so that V0 should be greater than zero

Lets take $V_{IN} = 7.2V$

$$R_X = \frac{7.2\ X\ 50K}{12.80}$$

$$= 28.12\ K\Omega$$

The variable resistor of 50 KΩ is set at 28.12 KΩ in order to obtain an output voltage. $V_0 > 0$. Any value above 28.12 kΩ , its equivalent voltage will hold the op amplifier ON but care must be taken in such a way that V_{IN} is les than 8v, which is V_{DD}. If $R_X < 28.12\ K\Omega$, $V_0 = A\ (V_{IN} - V_Z) = 0$ because $E = V_{IN} - V_Z < 0$

2.7.2 THE SELECTION OF THE ZENER DIODE

The commercially available zener diodes have breakdown (threshold) voltages ranging from 2 to 500 V and with current rating from few milli amperes to many amperes. On the circuit zener diode of 7.1V, 0.5 W is used as voltage stabilizer to supply the inverting input of amplifier. This is the most common use of zener diode and is based upon the fact that the voltage across the diode remains almost constant for wide variation input voltage once breakdown occurred.

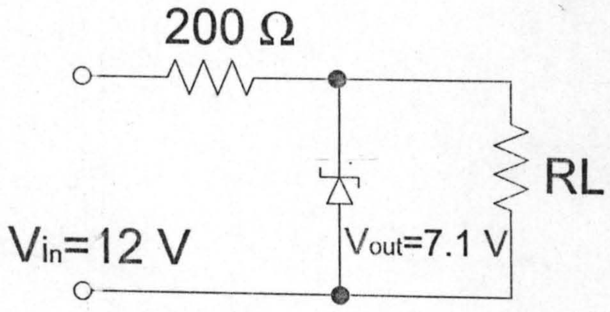

Fig.2.13 Zener diode circuit

Calculation of R_X

$I_t = I_Z + I_L$

The maximum zener current $I_{Z\,(max)}$:

$$I_{Z\,(max)} = \frac{Z\,(max)}{V_Z}$$

$P_{ZMAX} = \frac{1}{2}$ W

$V_Z = 7.1V$

Therefore $I_{ZMAX} = \frac{P_{ZMAX}}{V_Z}$

$$= \frac{0.5}{701}$$

$$= 7.04 \text{ X } 10^{-2}$$

$$= 70.5 \text{ mA}$$

under no load condition 70.5 Ma flow though the zener diode then It = Iz since IL = 0 Rs must limit the current so that with RL disconnected it will not greater than 70.4 mA.

$$RS \text{ X } VS = \frac{VIP}{I_{ZMAX}} = \frac{128 - 7.1}{I_{ZMAX}} = \frac{8.009 \text{ X } 12\text{-}2 \text{ K}\Omega = 80.9 \text{ K}\Omega}{70.4}$$

A nearest value of the resistor is chosen to be 100Ω

2.8 DESIGN OF THE DECODER

A decoder is a logic circuit, which has a set of input typically thee and as set of outputs. One output is activated for each possible binary input pattern occurring. There are up to eight different possible binary input patterns and therefore eight outputs are required. The first output is activated when the pattern 000 occurs on three inputs, the second output is activated when the input pattern, 001 occurs and so up to eight output when the input pattern is 111

2.8.1 DESIGN TECHNIQUE

As said above logic circuit is either combinational or sequential. The method of designing adopted in this project follows the combinational method circuit arrangement. The electric power supply authority (NEPA) distributes three phases to consumers. The relationship between the various switching stages is symbolized as follow.

R: red phase

Y: yellow phase

B: blue phase

R_R: Relay energizing red phase

Y_R: Relay energizing yellow phase

B_R: Relay energizing blue phase

R = Y = B = 0 = low potential or non active line

R = Y = B = 1 = normal potential or active line

$R_R = Y_Y = B_R = 1$ phase relay de-energized

$R_R = Y_R = B_R = 0$ phase relay energized

CONSRUCTION OF TRUTH TABLE

R	Y	B	RR	YR	BR
0	0	0	0	0	0
0	0	1	0	0	1
O	1	0	1	0	0
0	1	1	0	0	1
1	0	0	0	1	0
1	0	1	0	0	1
1	1	0	0	1	0
1	1	1	0	0	1

Table 2.2 Truth Table For The Decoder

These variables symbol are used since R, Y, B are used in Nigeria by power system for identification of red, yellow and blue line respectively. The truth table represent the available input variable with their eight combination and their corresponding output to the relay. From the table we can derive different equation for each relay.

$R_R = \overline{R}\ Y\ \overline{B}$

$Y_R = \overline{RYB} + R\overline{Y\ B}$

Using karnaugh map equation 2 and 3 to minimized

For $Y_R = \overline{R\ Y\ B} + R\ Y\ \overline{B}$

B/RY	00	01	11	10
0	0	0	1	1
1	0	0	0	0

Table 2.3a Karnaugh Map

The simplified $Y_R = R\ \overline{B}$

For $BR = R\ \overline{Y\ B} + R\ \overline{Y}\ B + R\ Y\ B + R\ Y\ \overline{B}$

B\RY	00	01	11	10
0	0	0	0	0
1	1	1	1	1

Table 2.3b

The simplified BR = B

The red relay equation does not require simplification therefore RR = R Y B . From the following equation the switching circuit can then be drawn:

$R_R = \overline{R}\,Y\,\overline{B}$

$Y_R = R\,\overline{B}$

$B_R = B$

The switching circuit can then be drawn as follow

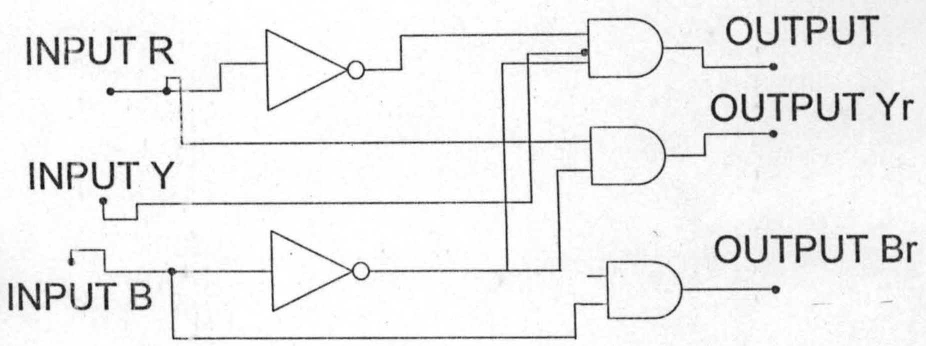

Fig 2.14 Switching Circuit

This switching circuit shown above comprises two logic gate, an inverter and an AND gate which can be designed by using two CMOS Ics.

CD4069: a 14 pin integrated circuit with six not gate, the supply V_{DD} and the ground

MC4073: it is a 14 pin integrated circuit with triple three inputs AND gate, the supply V_{DD}.

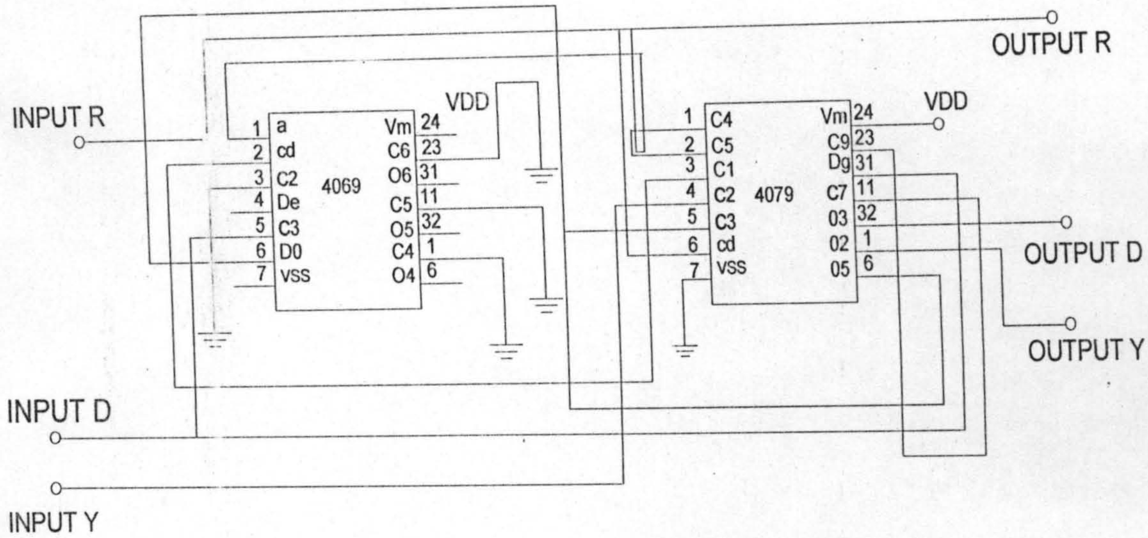

Fig 2.15 Decoder Circuit

R: the output of comparator which has its non-inverting input supplied by red phase

B: the output of the comparator which has its non-inverting input supplied by blue phase

Y: the output o the comparator, which has its non-inverting input, supplied by yellow phase

BR: the output of the AND gate the blue phase relay

RR: the output of the AND gate to energize the red phase relay

YR: the output of the AND gate to energize the yellow phase relay

In CMOS circuit both logic level are relatively generated allowing a low impedance output drive at each logic. This means that CMOS devices have very low power consumption; CMOS ics may be operated from a wide range of supply voltage (3 to 18v typically) making them very suitable for battery powered operation.

Logic o is defined as being between 0 – 3 percent of the supply voltage while logic 1 is greater than 70% of the supply. For this circuit, the Ics, are supplied by VDD = 8V. therefore the logic o is defined between:

$$V1 = 0V \text{ and } V2 = \frac{8 \times 30}{100}$$

=2.4V

The logic 1 is defined between:

$$V' = \frac{8 \times 70}{100} = 5.6V$$

V" = 8V

Each logic level is actually specified as a range of voltage with an invalid zone between the two logic levels.

2.9 THE DESIGN OF DRIVER

The driver employed in this project is BXS20 NPN transistor, which acts like an electronic switch, which is used to control a power relay of 6V d.c 6A

The characteristics properties of BXS20 NPN transistor is:

$BV_{CBO} = 75V$

$BV_{CEO} = 40V$

$BV_{BEO} = 6V$

Maximum collector current = 0.8A

Maximum device dissipation power = 0.500W

Current gain = 200

From the above characteristic the base current of BXS 20 transistor can be found:

$$I_B = \frac{I_C}{h_{FE}}$$

I_B = base current

I_C = collector current

H_{FE} = current gain

$$I_{B(MAX)} = \frac{0.8}{200}$$

$$= 0.04A$$

$$= 40mA$$

From analyzing the circuit diagram, the base of the transistors are supplied by the output of the AND gates and these outputs are high with the output voltage between

5.6 and 8 V. The maximum base current is 40 mA then the base resistor can be calculated:

For $v_0 = 5.6V$

$$R_B = \frac{V_0}{I_B} = \frac{5.6V}{40mA} = 0.14\ K\Omega$$

For $V_0 = 8V$

$$R_B = \frac{8V}{40mA}$$

$$= 0.2\ K\Omega$$

Any resistor value failing between 0.14 and 0.2KΩ can be used as the base resistor. The ON- state of the switching transistor BXS 20 controls the relay of the circuit and the freewheeling or the clamp diode across the coil prevents voltage spikes which may be induced in the system.

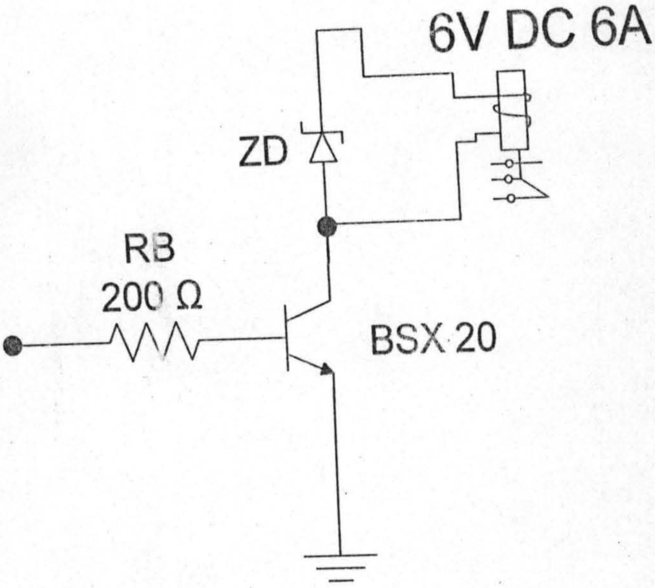

Fig 2.16 Driver Circuit

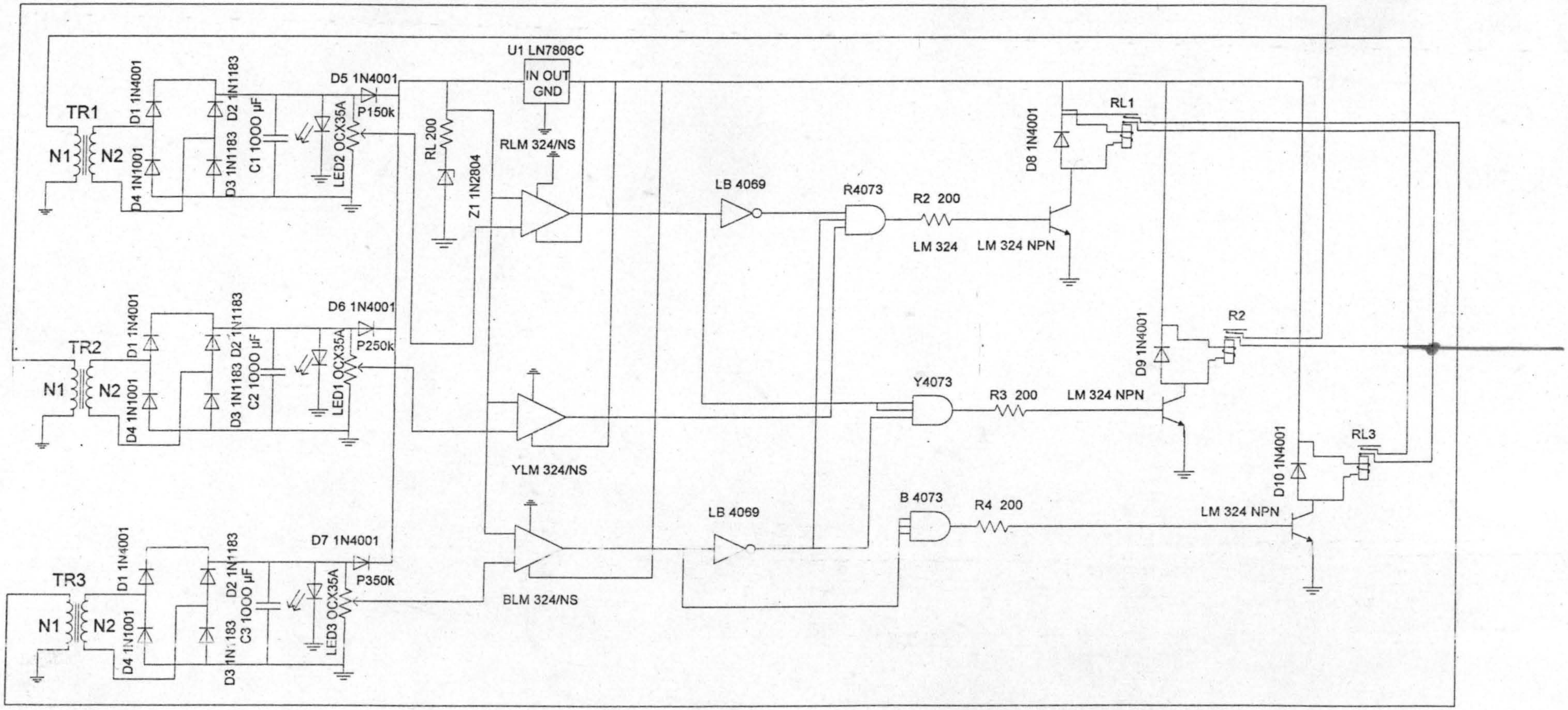

FIG 2.17 CIRCUIT DIAGRAM

CHAPTER THREE

CONSTRUCTION, TESTING AND DISCUSSION OF RESULT

3.1 CIRCUIT CONSTRUCTION

The circuit construction is divided into two:

The power supply unit

The control circuit and the driver

They are built on a single circuit board measuring 60 X 140 m. The construction work started first by designing the component layout for the system shown in figure 2.9 and then implemented on a board. This was done in such a way that minimal space was used. A 14 pin dual IC socket was used to plug the ICs into the circuit board. The way of connecting the ICs is of great importance and carefulness because it aids troubleshooting enormously as the ICs could be removed when making checks.

The ICs were soldered on the board by using the ICs pins position as a guide. The others components were then fixed on the board in their various positions. Before soldering proper checking of components, connection was done. Polarized components such as electrolytic capacitors and transistors were checked to be sure that they were well fitted in the right way.

The choice of material used for the construction of the casing for system is based on the cost, the strength, reliability, and physical outlook of the equipment. It is a wooden casing, which is perforated for ventilation reason of the system on operating; it is prevented from any risk of short circuitry of the soldered components because the wood is a good insulator.

3.2 TESTING

The testing was carried out systematic following the block diagram of the system representation. The power supply unit was actually tested first. When the appliance was connected to the power supply mains the system was discovered to function as desired.

3.3 DISCUSSION OF RESULT

Various appliances are connected to the output of the device. Each of them is performing its normal function once it was switched on. The output of the device is measured and it is found to be the highest between the three inputs of the devices.

CHAPTER FOUR

CONCLUSIONS AND RECOMMENDATION

4.1 CONCLUSION

The design and construction of this project has not been an easy task. It has called for precision and carefulness especially in designing and construction of the control part of the circuit, which was where the most problem was encountered. It has been a good working control unit and this was achieved by selecting appropriate and convenient value for the components gotten from design and calculation

4.2 RECOMMENDATION

It is recommended that to improve the performance of the system depending on the desire and design, the output of this device be designed in such a way as to make it possible to be regulated so that it would be properly useful for domestic supply required by IEE regulation.

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