DESIGN AND CONSTRUCTION OF AN AUTOMATIC TEREE PHASE CHANGER.

By

SALEEMAN IBRAHIM BUKOLA
99/9352EE

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
SCHOOL OF ENGINEERING AND ENGINEERING TECNOLOGY
FEDERAL UNIVERSITY OF TECHNOLOGY
MINNA, NIGERIA.

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A PROJECT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF ENGINEERING (B.ENG) DEGREE IN THE DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING, SCHOOL OF ENGINEERING AND ENGINEERING TECNOLOGY, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGER STATE, NIGERIA.

NOVEMBER, 2004.

DECLARATION

I, Saleeman Ibrahim Bukola, hereby declare that I carried out this project work, under the supervision of Engr. Abraham Usman.

.... 7-12-04

Signature Date

CERTIFICATION

This project work Automatic Three Phase Changer was to the best of my knowledge carried out by Saleeman Ibrahim Bukola and presented to the Department of Electrical and Computer Engineering, Federal University of Technology, Minna, Niger state in partial fulfillment for the award of Bachelor and Computer Engineering.

7/12/04

....

Mr. Abraham Usman
(Project Supervisor)

Date

31/08/2005

....

Engr M D Abdullahi
H.O.D

Date

....

External Supervisor

Date

DEDICATION

This project report is dedicated to my parents Engr S. O. Saleeman and Alhaja H. I. Saleeman and to all my sisters: Ashiat Saheed, Musilmat; Dhikrat; Aisha; and Aminat Saleeman.

ACKNOWLEDGEMENT

Praise be to Allah the Lord of the Universe who spared my life and guided me and blessings of Allah be upon Mohammed (SAW) through whom Allah has sent his guidance to mankind. I pray Allah should continue to guide us onto the right path.

My profound gratitude goes to my supervisor Engr Abraham Usman for his contribution and suggestions towards my project.

My enormous gratitude to my parent Engr. S. O. Saleeman and Alh. H. I Saleeman who nurtured me and imbibed in me the fear of Allah. I thank them for their support morally and financially.

My regards to Engr Saka for all the assistance rendered and brotherly advice given to me. My acknowledgment will be incomplete without mentioning my colleagues friends and well wishers like Abdusalam B.B, Habeeb G.A. Seun Afolabi, Ibrahim Motolani, Aishat Abubakar, Afusat Saidu and most of all my motivator Sister Bilqees Kazeem. I thank you all may Allah reward everybody accordingly.

ABSTRACT

This project work present design and construction of an automatic three-phase changer. The circuit work together to select among available phase of lines that has voltage supply whenever there is a power failure in any of the phases provided there is a phase with voltage supply. The power supply unit provides output voltage that has been rectified and filtered by filtering circuit; it is kept at regulated value 12v by voltage regulator, which is used to power the IC's and other electronic components. The control circuit comprises of comparator LM 339, decoder 4028B and switching transistor, which energizes or de – energizes the relays: a relay is energizes at a time to deliver voltage supply to the load.

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CHAPTER ONE

GENERAL INTRODUCTION

1.1 INTRODUCTION

Electric power is a little but like the air we breathe, you don't really think about it until it is missing. It is of great importance in this present society of ours due to its large areas of applications. Electric power supply has found its application in medicine, agriculture and industry as a labour saving device for comfort and preservation in our homes. There is no doubt at all that versatility of electric power has given us great dominance we now exercise over nature.

The problem of power outage along transmission and distribution lines in a developing country like Nigeria is no more a news. The major causes of these outages are as a result of mechanical stress, overloading, temperature variation, transient current caused by fluctuation of power system and equipment failure. These outages causes a lot of loss and hardship such as ; no water supply, no power supply for cooking activities, industries experiencing loss in production as machines cannot function without power supply and even loss of lives as seen in those equipment [oxygen mask] used in the theatre room during surgical operations.

The use of three phases in some places like hospital, industries, communication firms has drastically reduce this problem since it is not the routine of national electric power authority [NEPA] to shed load of three – phase of a particular environment except there is a major fault along the transmission and distribution lines. The use of automatic three phase changer is to monitor the three phase supply from NEPA and decide which phase to be connected to the consumer terminal whenever there is a power failure with voltage supply available in one or two phases. The switching is achieved without human intervention.

The project is designed and constructed in such a way that the device selects and delivers continuously voltage at the output, provided there is at least one phase with voltage supply among the three phases. The device operates with the comparator feeds with appropriate input to generate logical outputs. The logic phase selection circuit process these selected input selected inputs from the comparator. The output of the phase selection circuit feeds the base of the switching transistor to activate the relay which close and open depending on the state of input base voltage. The contact of relay is connected to a phase of NEPA supply.

1.2 PROJECT OBJECTIVES

The project is aimed at constructing automatic three phase changer with capability to select a phase with voltage supply and delivers the supplied voltage to the load continuously in as much there is at least a phase with voltage supply among the three phases without human intervention.

1.3 LITERATURE REVIEW

Power supply has been found to be unstable and unreliable ever since; hence the need to improve the availability and efficiency of power supply became more pronounced leading to different approach in order to improve the availability and efficient power supply. One of the approach was the introduction of automatic voltage nearly constant over a range of variation of input voltage. This method minimized voltage variation thus ensuring satisfactory and efficient operation of equipment.

Another approach employed was the uninterruptible power supply, which is used as an alternative or back up supply ensuring continuous supply of adequate and efficient power supply. The introduction of automatic three phase changer whose function is primarily to ease the issue of switching from a phase under load shedding to the one that has voltage supply manually. It is more advantageous than the manual way of changing fuses from one phase to the other. which involves complicated wiring and more tasking in its mode of operation.

This project limits its study to automatic three phase changer which is in position to select among the available phases of line with voltage supply and switches itself to another phase with voltage supply when there is power failure in any of the phase to which it has previously assumed state.

1.4 PROJECT OUTLINE

Chapter one covers the introduction, project objectives,. Literature review and project outline. The description of components is treated in chapter two and deals with the power supply, comparator, decoder and the driver circuit. The third chapter covers the design calculations; how the value of the components is determined. The fourth chapter deals with the construction and testing of the project. Finally conclusion and recommendation are discussed in chapter five.

CHAPTER TWO

SYSTEM ANALYSIS

2.1 POWER SUPPLY

DC Power supply is a basic electronic system generally consisting of transformer, rectifier, filter and a regulator in the case of regulated D.C. power supply that convert AC Voltage to DC Voltage. Most electronic system operates from a low voltage DC power supply which is usually derived from AC Voltage supply from NEPA. A typical power supply consisting of four stages shown in figure 2.1.

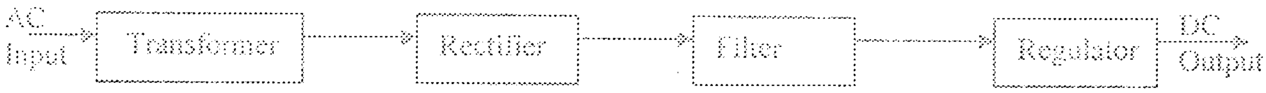


Fig 2.1. Block diagram of a typical power supply.

2.1.1 TRANSOFRMATION

The transformation stage consist of a transformer which is an electromagnetic component used to change are alternating voltage level to another. In case of transformer used for DC Power supply, it step-down AC Voltage to be small value which is more suitable for supply after rectification as required by electronic system. The transformer consisting of two separate coils also provide essential isolation between electrical or electronic system and ac main supply. The primary and secondary winding each several turns of varnished copper wire are unlike together by a magnetic circuit. It is assumed that magnetic coupling between the primary and secondary windings is 100% that is all the primary fine unirs the secondary coil. In such cases, the turn ratio and voltage ratio are related by formula

VP/VS = NP/NS 2.1

It is also assumed that no power is lost between the primary and secondary during the transformation process. That is

$I_P V_P = I_S V_S$ 2.2

From here, the current ratio is

$I_P/I_S = V_S/V_P = N_S/N_P$ .... 2.3.

The transformation circuit is shown in figure 2.2.

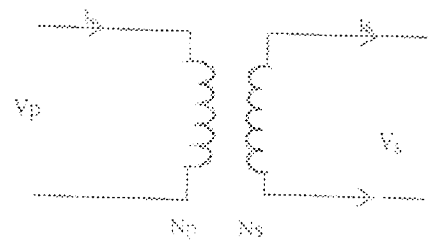


Fig 2.2. Transformation circuit

2.1.2 RECTIFICATION

Rectification stage comprises of diode which convert AC voltage to pulsating DC voltage. This is possible due to the characteristic of a diode when forward biased (which allows flow in the forward but blocks in the reverse direction).The two types of rectifiers circuit in use are half wave and full wave rectifier. The full wave bridge rectifier was employed in this project because the ripple effect in full wave rectifier is less compared to half-wave rectifier. In full wave bridge rectifier four discrete diodes arranged in bridge network are need. During the first half cycle D1 and D_3 conduct and during the second half cycle D_2 and D_4 conduct, hence current flow in both halves giving rise to full rectification. The rectification circuit and the output waves from are shown in figure 2.3.a and 2.3.b respectively.

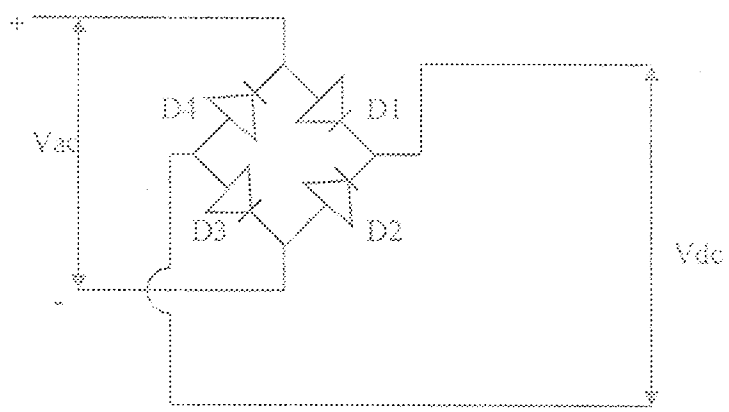


Fig 2.3a Full wave bridge rectifier

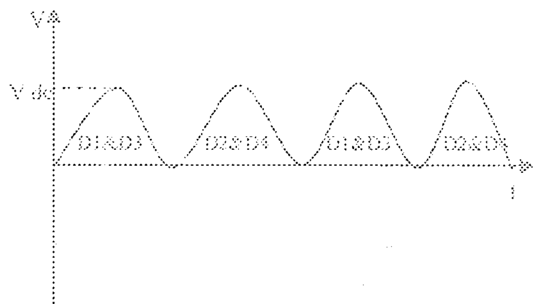
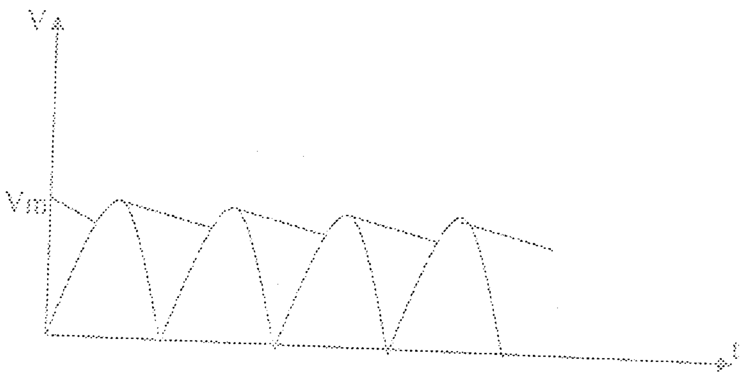


Fig 2.3b Output waveform of full wave bridge rectifier

2.13 FILTERING

The filtering stage converts the pulsating DC to a very steady DC level. Various filter circuit exist such as the series capacitor, shunt capacitor series inductor filter configuration. However the shunt capacitor filter was best suited for the purpose of this project. The shunt capacitor is usually a single electrolytic capacitor connected across the rectifier and parallel to the load so as to achieve filter action. The required filtering action depends on the property of a capacitor to store energy during the conduction period and delivers it to the load during non-conducting period; hence the time of flow through the load is prolonged. The smoothing action of the shunt capacitor is shown in figure 2.4.



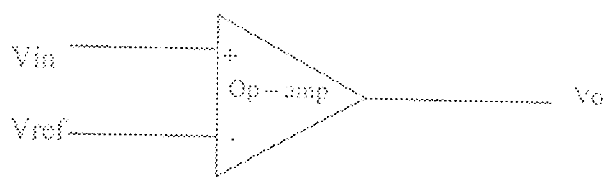
For 2.4. Smoothing action of a shunt capacitor

2.1.4 REGULATOR

Voltage regulation within the power supply circuit which is the final stage of power supply is necessary in order to provide a stable DC voltage independent of the local current and ac line voltage variation. Electric voltage regulation is achieved through the use of regulator ICs which comes in various ratings, three terminal voltage regulator IC was used for the project. One terminal as input, the other as output and the third as the common ground.

2.2. COMPARATOR

A comparator circuit is one that compares a signal (voltage) applied at the input of an op-amp with known reference voltage at the other input. the reference voltage is usually adjusted to desired value. Comparator is basically an operational amplifier (op amp) with an output that is normally constrained to level suitable connection to digital large circuit. Fire 2.5. Shows the schematic representation of an op-amp configures as a comparator.



2.5 Schematic diagram of a comparator

The terminal with the negative sign is referred to as inverting input while the terminal with positive sign is referred to as non-inverting input. The inverting input is set as the reference voltage while the time varying input voltage (signal) is fed in through the non-inverting input.

2.3 LOGIC PHASE SELECTION CIRCUIT

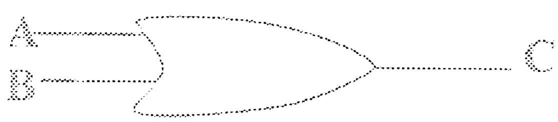
The logic phase selection circuit comprises of a decoder and or gates forming a combinational circuit. It is used to achieve phase selection by diverting only one output at a time

2.3.1 DECODER

A decoder is one of the simplest and most useful types of multiple output circuit encountered in digital system. It is a combinational circuit with n-input and at most 2^n output; and its characteristic property is that for very combination of input one output is selected. A decoder can be constructed from discrete gate, which are used in solving logical problem. For the purpose of this project 3 to 8 decoder is employed.

2.3.2. OR GATE

The OR gate has an output one (1) when any or all input are one (1). The electronic symbol for a two-input OR gate is shown in fig. 2.6. It has an output of one (1) when either A or B or both are one (1).



2.6 OR gate

2.4. DRIVER CIRCUIT

The driver circuit, which is also referred to as the switching circuit, consists of an electronic circuit, which manipulates its input signal to accomplish a specific objective of the system (its output signal). The driver circuit comprises of switching transistor and relay. Fig. 2.7. Illustrates the driver circuit.

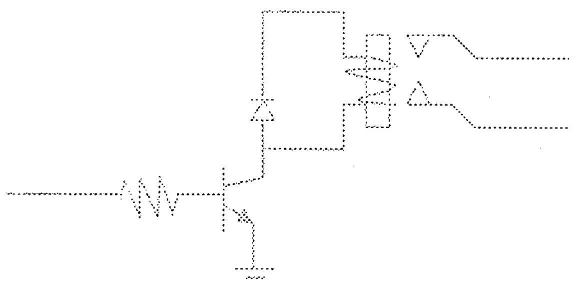


Fig 2.7. Driver circuit

2.4.1. SWITCHING TRANSISTOR

A transistor is normally operated in the linear region with the emitter-base junction forward and collector-base reverse biased. However, practically no collector current will flow when reverse biased and the transistor is said to be in is cut off region. The switching operation of a transistor is explained with the aid of figure 2.8

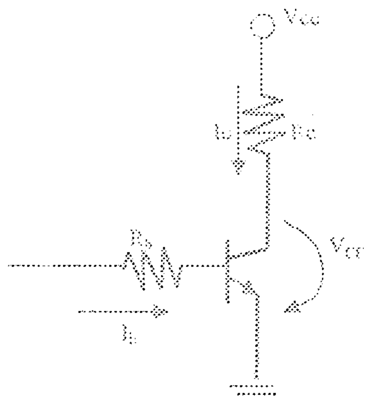


Fig 2.8. Switching operation of transistor

$VCE = VCC - ICRC$ 2.4

If $I_B = O$, then $IC = O$ (neglecting leakage current) Hence, $VCE = VCC$

Under this condition, the transistor is said to be in the cut off region. In this state the transistor act like an open switch. If the value of R_b and R_c are such that VCE comes to zero, then the transistor is said to be saturated. Putting VCE to be equal to cero equation 2.4. above we have that

$VCC = I_C R_C$ 2.5

A transistor when saturated act like a closed switches of negligible resistance. It is obvious that under saturated condition collector current is maximum and whole of Vcc is dropped across R_c. Hence, It can be seen that the normal operation of transistor lies between the two extreme condition of cut off (OFF POSITION) and saturation (ON POSITION). The transistor switch is useful because it is fast in response and it operates effectively in transmission of digital signal.

2.4.2. RELAY

Relays are electromechanically operated switches. It basically consist of electromagnet which operate a pair electrical contact to effect the operation of other devices in the same or another circuit. In usual type it requires a small amount of current to energise the electromagnet which causes the movement of the armature and hence, the closure of the contacts. Such relays are very useful, for example alarm and buzzer.

For this project the relay is activated (transistor indicating) goes high and is deactivated when the output goes low. The diodes connected across the relay coil to save guard against inductive kick back of the relay coil.

CHAPTER THREE

DESIGN CALCULATIONS

The block diagram of automatic three phase changer is shown in fig 3.1. And incorporates the following units: power supply, comparator, logic phase selection and driver.

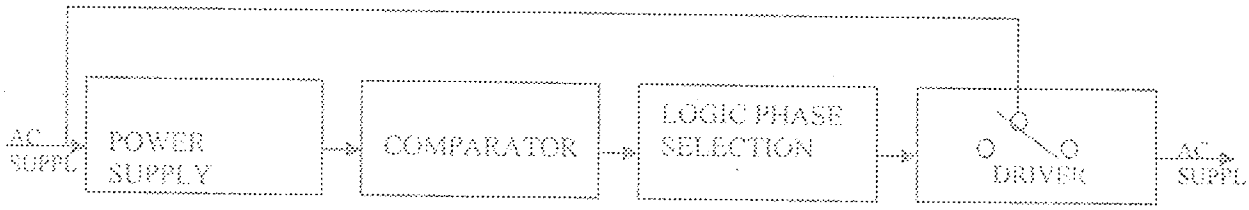


Fig 3.1 Block diagram of automatic three phase changer.

3.1. TRANSFORMER DESIGN CALCULATION

The three transformers needed for this project are step-down transformer, all of this project rating 240V/24V. Considering the power of each relay, maximum coil current drawn by the relay becomes.

$V = IR$

Coil resistance (R) = 400ohms

$V = 12$

$I = V/R/ = 12/400 = 0.03A$

$I = 30mA$

The power delivered to the relay becomes

$P = IV$

$= 30 \times 10^{-3} \times 12$

$P = 0.36VA$

Since three are three relays connected, the total power delivered to the relays become

$P = 3 \times 0.36$

$= 1.08VA$

The transformer VA rating is determined as follows:

Transformer VA rating = Power delivered to the load/ Transformer utilization factor.

$= 1.08/0.693 = 1.56VA$

Transformer VA rating = 1.56VA

The step-down transformer of 240OV/24V 300MA was chosen for the power supply unit.

3.2. RECTIFIER DESIGN CALCULATION

In designing the bridge rectifier the peak inverse voltage (PIV) of diodes is determined. The peak inverse voltage rating for each of the four diodes used in full wave bride rectifier is equal to Vmax

$V_{max} = 1.414 \times V_{rms}$

= 1.414 x 24

= 33.94V

Hence, the peak inverse voltage is equal to Vmax

PIV = 33.94V

A diode peak inverse voltage PIV rating of 100V was chosen as the rectifier. The diode type is IN4001 100V.

3.3. FILTER DESIGN CALCULATION

In order to minimise ripple content of the dc voltage from the output of the rectifier. A shunt capacitor filter was employed for this project to provide a very good smoothing of ac ripples from the output of the rectifier. The value of the shunt capacitor was determined as follows:

Vrip = Id.c/2fc 3.4

Vd.c = Vmax– Vrip 3.5

Substituting equation 3.4. into equation 3.5

Vd.c. = Vmax – Id.c/2fc

Vmax = 1.414 x 24

= 33.94V

In the power supply used for this project circuit the secondary load current of the transformer is I_L = 300mA. Therefore

$Id.c = 2X\ 2\ \lambda 300 \times 10^{-3}/ 3.142$

$Id.c = 0.27A$

Assuming a ripple factor of 0.115, Vrip = 5.09V, F = $50H_z$,

$C = Id.c/2 \ X\ Vrip\ X\ f$

$= 0.27/2\ X\ 5.09\ X\ 50$

C= 530uF

Since larger capacitor would tend to reduce the ripple magnitude therefore, a filter capacitance of 1000uF was used for this project. Fig. 3.2 shows the power supply unit.

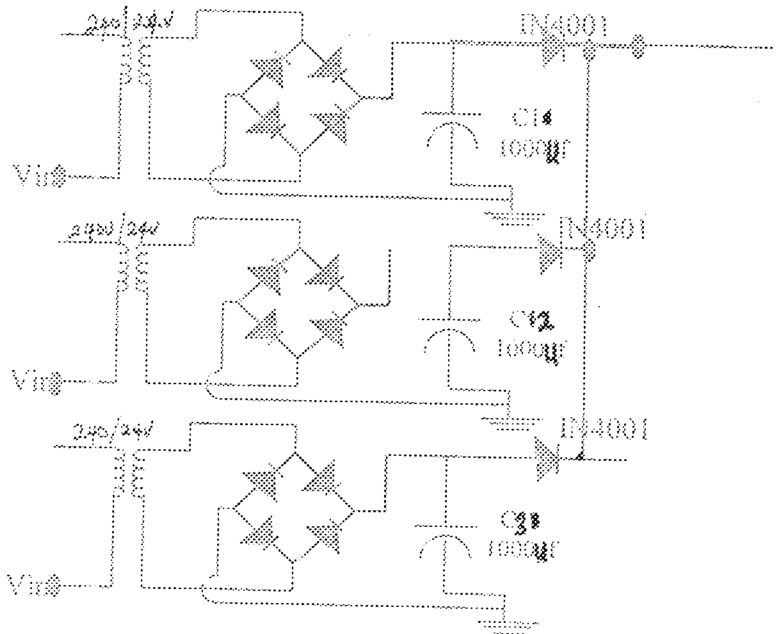


Fig 3.2. Power supply unit

3.4 THE SELECTION OF THE VOLTAGE REGULATOR

A three terminal voltage regulator IC (7812) was chosen to supply electronic devices. The pin definitions are: pin one is the unregulated input dc voltage, pin two is the ground and pin three is the regulated output voltage. This is illustrated in fig 3.3

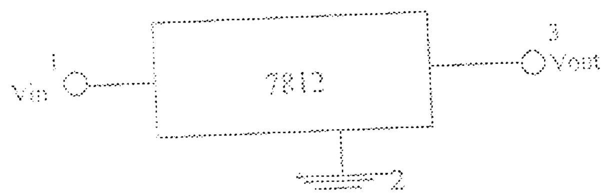


Fig 3.3 Voltage regulator

3.5 COMPARATOR CRICUIT DESIGN CALCULATION

The comparator IC used in this project is the LM339, which contains four OP-amps. It has an operating voltage as low as 1.5V.Figure 3.4. Shows the internal arrangement of the LM 339 IC

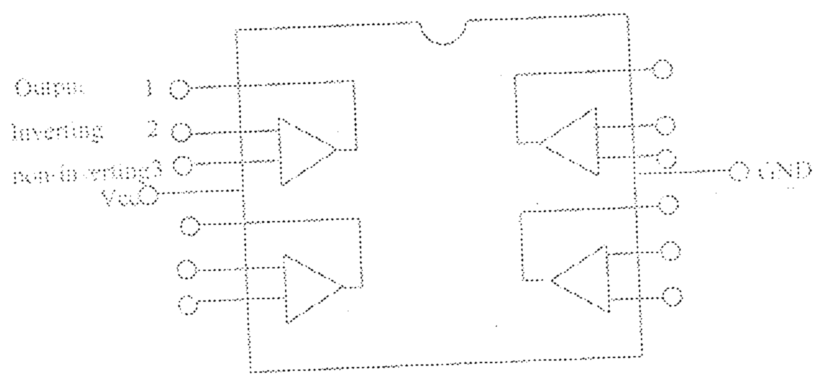


Fig. 3.4 Internal arrangement of LM 339 IC

Each comparator within this IC was design a shown in figure 3.5.. Therefore the need to determine the value of the variable resistor.

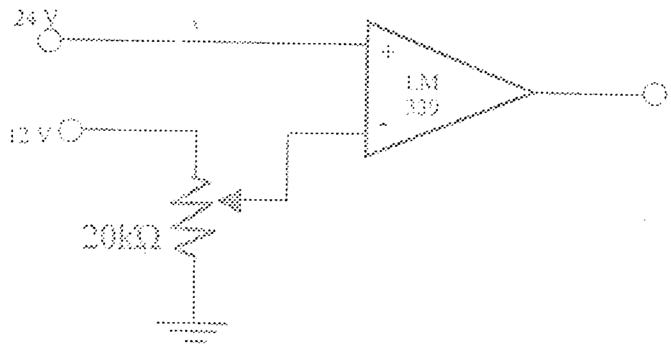


Fig 3.5 comparator circuit

To determine the value of the variable resistor. It was assumed that variable resistor comprises of two resistors R_1 and R_2 in series. The arrangement forms voltages divider network and is fed with voltage from the regulator which is the desire reference voltage. Since reference voltage that can be obtained by adjusting the variable resistor is 12V. A value of 5kΩ is assumed for R_1 and 3V as output voltage V1 across resistor R1. Fig 3.6 shows voltage divider network.

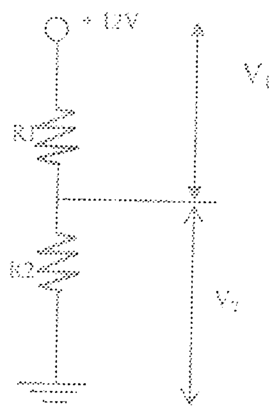


Fig 3.6 voltage divider network

$V_1 = V_T/R_1 + R_2 \times R_1$.. 3.7

$3 = 12/5k\Omega + R_2 X 5k\Omega$

$R_2 = 45k/3 = 15K\Omega$

Therefore $R_1 + R_2 = 5k\Omega + 15K\Omega = 20 K\Omega$

A 20k standard variable resistor was chosen.

3.6 DESIGN OF LOGIC PHASE SELECTION CIRCUIT

The logic phase selection of this project was designed by implementing the combinational circuit arrangement. It comprises of an IC 4028B (decoder) and diode or gate 4028B IC: It can be used as BCD to decimal decoder and as well as 3 to 8 decoder. It has 16 pins with four inputs, ten outputs, the supply and ground. It was employed as 3 to 8 decoder in figure 3.7.

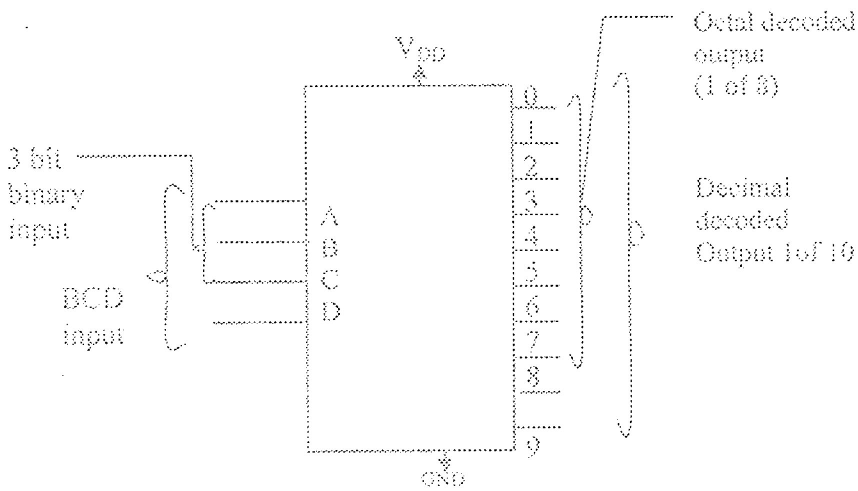


Fig 3.7 functional diagram of 402SB IC

It operates within the range of supply voltage 3V to 18V. For level, the voltage level is within the range 0V to 3.6V and for high level the voltage range is between 3.6V and VDD. IN4001 diode with peak inverse voltage of

100V was used to implement the OR gate. Overall connection for the logic phase selection circuit showing the decoder connected to the OR gate is illustrated in fig. 3.8

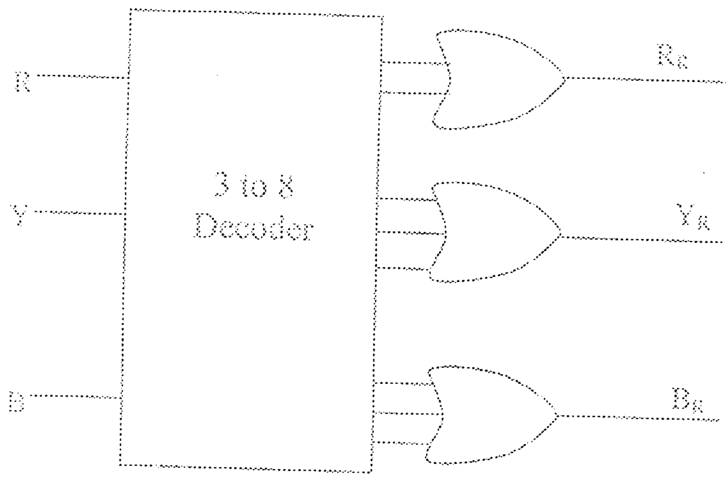


Fig. 3.8 Overall connection of logic phase selection circuit

The inputs of the phase selection circuit with their possible combination are expressed in form of truth table. However, the truth table that can be directly related to this project if 1 and 0 denote active line and non active line respectively. R-Y-B denoted Red, Yellow and Blue phase respectively. The truth table contains all possible combination of R, Y, B, Phase (input variable) and the desired R_R, Y_R and B_R corresponding to each combination. The table shows the truth table.

Available input Variable			Desire output variable		
R	Y	B	R_R	Y_R	B_R
0	0	0	0	0	0
0	0	1	0	0	1
0	1	1	0	1	0
1	0	0	1	0	0
1	0	1	1	0	0
1	1	0	0	1	0
1	1	1	0	0	1

Table 3.1. Truth table

$$\left.\begin{matrix} R_R \\ Y_R \\ B_R \end{matrix}\right\} = 0 \text{ phase relay de-energised}$$

$$\left.\begin{matrix} R_R \\ Y_R \\ B_R \end{matrix}\right\} = 1 \text{ phase relay energised}$$

$$\left.\begin{matrix} R = 0 \\ Y = 0 \\ B = 0 \end{matrix}\right\} \text{ non – active line or low potential}$$

$$\left.\begin{matrix} R = 1 \\ Y = 1 \\ B = 1 \end{matrix}\right\} \text{ active line or high potential}$$

3.6 DRIVER CRICUIT DESIGN CALCULATION

The driver circuit comprises of transistor and relay. The relay used is 10A 12Vdc with coil resistance of 400Ω. A diode is connected across the relay coil to save guard against inductive back of the relay coil. The transistor used is the BC 108 NPN transistor with current gain hfe = 150 $V_{BE(Sat)}$ = 0.7V and maximum collector current = 0.8A

I_b = IC/hfe ……………………………… 3.8

= 0.8/150 = 0.00053A

Ib = 5.3.mA

From analyzing the current diagram, the base of the transistor is supplied by the output of the logic phase selection circuit. These outputs are high with output between 3.6V and 12V. The maximum base current is 5.3mA then the base resistor can be determined.

$R_b = V_o - V_{BE(Sat)}/I_b$…………………………………… 3.9

= 12 – 0.7/5.3.mA

= 2132Ω

R_b = 2.132 KΩ

Therefore, resistor standard value of 2.2KΩ was used as base resistor for the transistor.

CHAPTER FOUR

CONSTRUCTION AND TESTING

4.1 CIRCUIT CONSTRUCTION

The component were arranged and mounted on the breadboard. Plugging in the components using flexible connection wire to link the component together temporary did the arrangement on the breadboard. The circuit was tested and was functioning to expectation. The whole circuit was later transferred and mounted on the Vero board in such a way to economic space without making the wire look cumbersome and rough, then soldering component leads stage by stage for permanent connection on the Vero board.

Transformers used were firmly screwed to the bottom of the casing. Due to the effect of heat produced during soldering which can damage the integrated circuit components, integrated circuit socked were used so as to protect the integrated circuit component from the heat which impairs their effective operation. Transistors, diodes, resistors. Relays were all soldered with extra care as much as possible to avoid being damaged. Bad soldering was avoided at all stages of the construction. The complete circuit diagram of automatic three phase changer is illustrated in fig 4.1

4.2. CASING

The project is based on cost, reliability and physical outlook of the device. The casing of the project is made of wood. All necessary dimensions were taken into consideration. Holes were drilled on the surface of interest and case was assembled together.

4.3 TESTING

After all the construction work was done a test of reliability and continuity was carried out on the project going from one stage to another to ensure effective operation of the individual circuit. Overall performance test was carried out with the prototype powered with the voltage supply from NEPA.When all the lines (Phases) were powered the relay that was energised was noted. Several testing were carried out for all possible combination and the output results were noted. It was observed that the device operates in conformity with the aim of the project.

Table 4.1 shows the results obtained during the testing of the project.

R	Y	B	SELECTED PHASE
0	0	0	None
0	0	1	B
0	1	0	Y
0	1	1	R
1	0	0	R
1	0	1	Y
1	1	0	Y
1	1	1	B

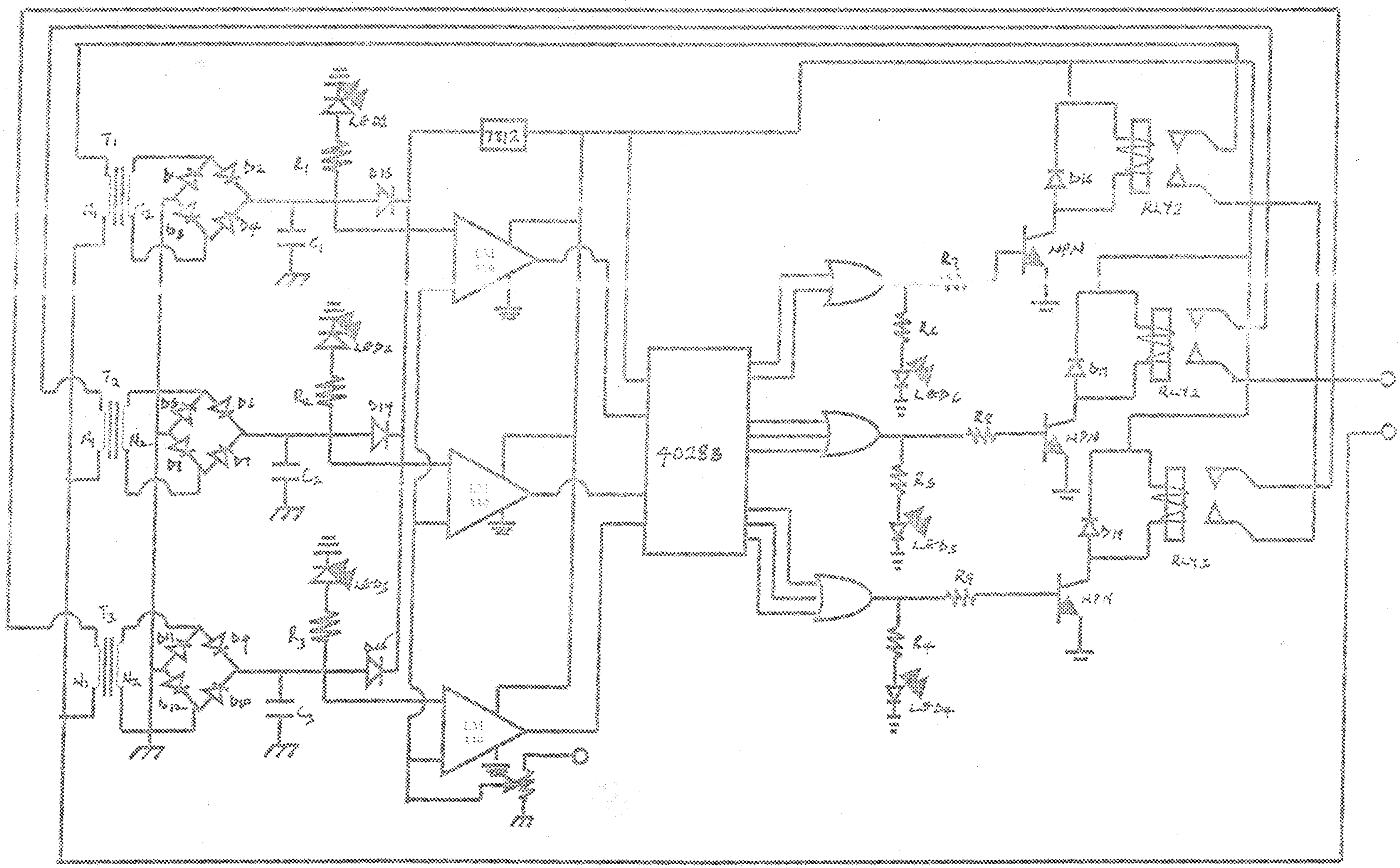


Fig 4.1.

Complete circuit Diagram of an Automatic Three phase changer.

The values of the components used are as follows

$D_1 - D_{18}$ = IN 4001

$C_1 = C_2 = C_3$ = 1000μF

$R_1 - R_6$ = 1KΩ

$R_7 - R_9$ = 2.2 KΩ

Variable resistor R_{10} = 20KΩ

$RLY_1 = RLY_2 = RLY_3$ = 12V Relay

LM339 IC

4028B IC

BC108 NPN Transistor

$T_1 = T_2 = T_3$ = 240V/24V Transformer

Light Emitting Diode (LED)

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1. CONCLUSION

The design and construction of automatic three phase changer has not been without its own problems. It is worthy to note that the OR gate (IC) which was supposed to be used not available. Therefore, an equivalent OR gate as designed using diodes. A good working control unit was chosen using the right specification while building the project in order to achieve proper operation of the relays. In conclusion, the purpose of the project was achieved but not without some difficulties encountered during the construction and testing.

5.2 RECOMMENDATION

The design and construction of this project has called for precision and carefulness especially in designing and constructing of the control part of the circuit. To improve the performance of the system, the output of the device can be regulated so that it would be conveniently being applied to sensitive equipment.

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