DESIGN AND CONSTRUCTION OF AUTOMATIC PHASE EXCHANGER

BY

SEKONI MUSTAPHA M.

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DEDICATION

I dedicate this project to Almighty Allah, the most beneficent and most merciful who has always been there for me, and to my wonderful parents Mr. and Mrs. Sekoni for their unending support. May God bless you and grant you long life to enjoy the fruit of your labour.

Certification

DECLARATION

I, Sekoni Mustapha Mohammed, declare that this was done by me and has never been presented elsewhere for the award of a degree to the best of my knowledge. I also relinquish the copyrights of this project to the Federal University of Technology, Minna.

Sekoni Mustapha M.

(Name of Student)

17-12-2010

(Signature and Date)

Mal Bala A Saliu

(Name of Supervisor)

18/12/2010

(Signature and Date)

Engr. A.G Raji

(Name of H.O.D)

(Jan. 27, 2011)

(Signature and Date)

Engr. Dr. G. I. Ighalo

(Name of External Examiner)

25/1/11

(Signature and Date)

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ABSTRACT

The Automatic Phase Exchanger is design to select one phase among the three phases from the distribution network when there is power outage in one or two phase. It is made up of 3 AC contact relay with holding contact current of 30A (6.6 KW). It has three modes operation, the normal Operation Mode where all the phases have (220-240V), but the main output is selected from the default relay based on circuit design, the Shift Operation Mode, where a low voltage occur in the default line (phase 1) or slave relay (phase 2) cause the circuit to change from either phase I or phase II to phase III and the Emergency Operation Mode where a Toggle Switch is used to cut-off power supply from the house unit whenever there is an electrical fault or a new electrical installations is to be made.

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CHAPTER ONE

1.1 INTRODUCTION

The supplier services cable feeding an installation terminates in what is usually called the Service Fuse. In an ordinary house the service fuse is called as Cutout Fuse.

Generally Cutout Fuse is an electrical device that cuts off the electric current flowing through a circuit under abnormal conditions or it is a switching device that allows changing of power source. The most familiar household Cutout Fuse protects circuits against short-circuit or overloading to prevent fire and electrical shock.

To protect all components of a power system from short-circuits, overloads and, for a normal switching operations, **Cutout Fuses/Circuit-Breakers** are employed. These breakers are large switches that are activated automatically in the event of a short circuit or other conditions that produces a sudden rise of current. Because an excessive current forms across the terminals of the circuit breaker at the moment when the current is interrupted, some large breakers (such as those used to protect a generator or a section of primary transmission line) are immersed in a liquid that is a poor conductor of electricity, e.g. oil, to quench the current. In large air-type circuit breakers, as well as in oil breakers, electromagnetic fields are used to break up the circuit. Small air-circuit breakers are used for protection in shops, factories, and in modern home installations. In residential electric wiring, fuses were once commonly employed for the same purpose. A fuse consists of a piece of alloy with a low melting point, inserted in the circuit, which melts, breaking the circuit if the current rises above a certain value. Most residences now use air-circuit breakers.

Cutout Fuse are installed outdoors as a protective device in a public, to protect and distribute electricity to housing estates, shopping centers, colleges, ports, airports, telecommunication sites, factories and many other commercial and industrial installations.

1.2 MOTIVATION

In recent time, records of electrical accidents like electrocution and fire out break have been a major problem most consumers of electricity are facing. Several devices like circuit breakers and fuses have been introduced during electrical installation in order to reduce electrical hazard in our home and the general public. In some areas it has really helped but in our homes the effect is less because the devices require operator. The cutout fuse used during electrical installation in building is one of such devices. Most of the time, an operator must visit the cutout fusing board with the intention of switching from one power source to another when ever power outage occurs.

Several reports of accident as a result of the operator coming in contact with a live conductor during manual switching from one power source to another has been reported to body like OSHA. For this reason many users of electricity are now scared of moving close to the cutout fusing board.

In a country like Nigeria where the distribution lines consist of three Phases, (Red, Yellow and blue phase), partial power outage occurs most times .i.e. not all the phases goes off at the same time. Due to this reason many home and offices has been using more than one phase (Line) i.e. are connected to either the red, yellow or blue phase, so that they can switch from one phase to another if there is power outage. This has been made possible through the introduction of cutout fuses during electrical installations..

Technology as made it clear that nothing is perfect but improvement is all man need for a safer leaving. Therefore, introduction of automatic means of switching from one power source to another should be introduced during electrical installation. The automatic switching devices can be called AUTOMATIC PHASE EXCHANGER. This device will prevent the operator from the hazards in manual switching from one power source to another. When there is power outage on one phase, the Automatic Phase Exchanger does not require the operator to switch to other phases (lines), it does that automatically.

In countries with unstable power supply, different means have been employed to solve the problem of power outage. Among the method employed is the placement of safety devices like circuit breaker, fuses and Cutout fuses etc. during electrical installation, all this devices have really help to reduced the rate of power failure by serving as protective devices for the electrical devices but the need to improve stability of power supply cannot stop because of the advancement in technology day by day.

1.3 Aim and Objective

- To eliminate the risk of going near the cutout fusing board
- To prevent interruption of power supply
- To minimize cutout fuse changing time
- To protect electrical appliances from damage as a result of sudden increase in current.

1.4 Scope

The Automatic phase exchanger is design in a way that the cutout fuse select/switch from one phase to another automatically when a phase among the three phases goes off.

1.5 Methodology

The Project is designed using various steps and procedures to actualize and achieve the efficiency and reliability of the circuit design. Proper attention was given to these design parameters in order to generate the desired triggered signal.

The construction of the system is based on the method with available devices and other necessary components. Each units consist of different electronic components which perform different operations necessary for the overall of the system.

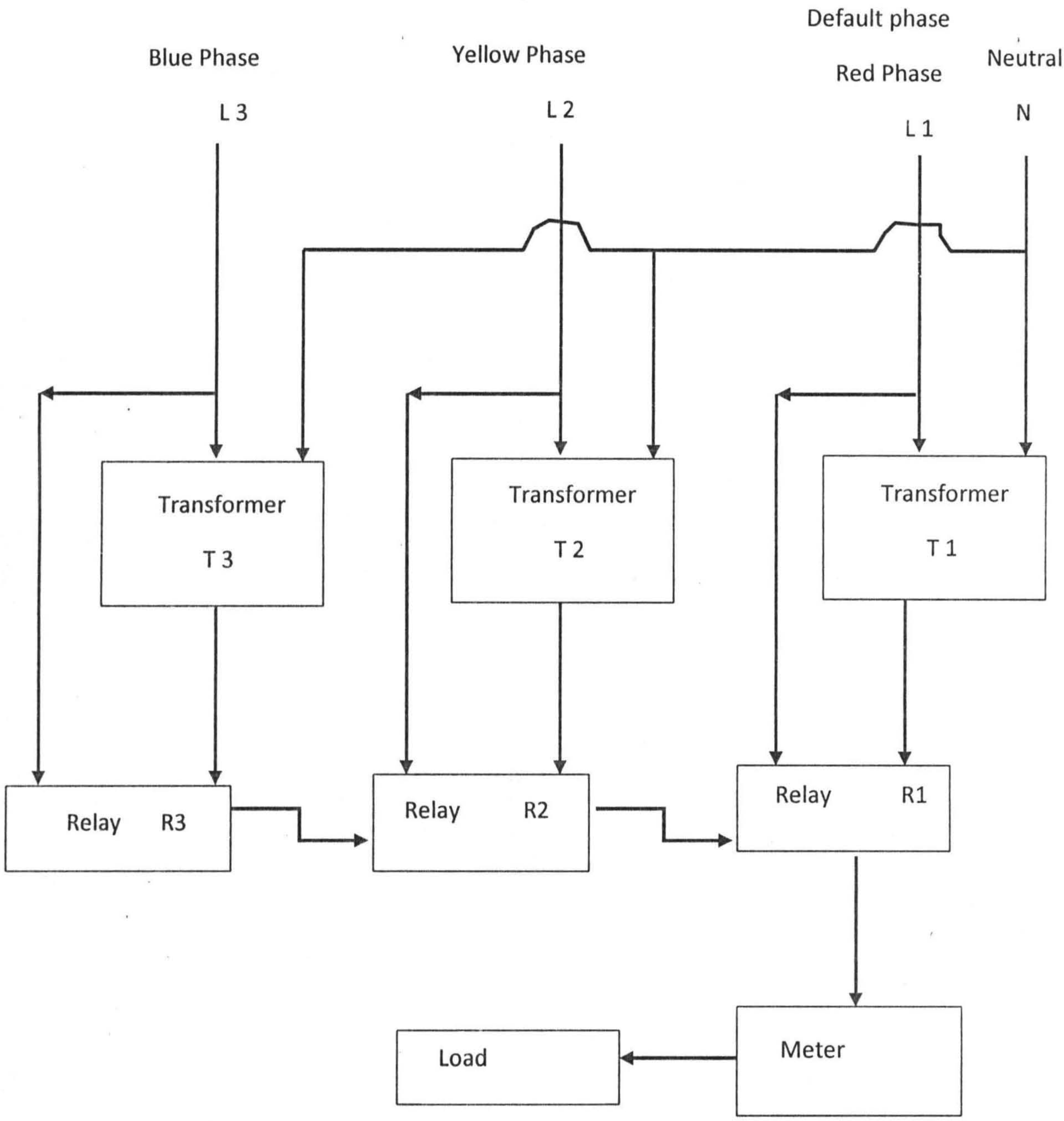


Fig. 1.1 Block Diagram of Automatic Phase Exchanger

The above figure shows the fundamental stages involve in the design and construction of the Automatic Phase Exchanger.

CHAPTER TWO

LITERATURE REVIEW

2.1 Background

Humans have known about the existence of static electricity for thousands of years, but scientists did not make great progress in understanding electricity until the 1700s, the ancient Greeks observed that amber, when rubbed, attracted small, light objects. About 600 BC Greek philosopher Thales of Miletus held that amber had a soul, since it could make other objects move. In a treatise written about three centuries later, another Greek philosopher, Theophrastus, stated that other substances also have this power [4].

For almost 2,000 years after Theophrastus, little progress was made in the study of electricity. In 1600 English physician William Gilbert published a book in which he noted that many substances besides amber could be charged by rubbing. He gave these substances the Latin name *electrica*, which is derived from the Greek word *elektron* (which means "amber"). The word *electricity* was first used by English writer and physician Sir Thomas Browne in 1646 [4].

The fact that electricity can flow through a substance was discovered by 17th-century German physicist Otto von Guericke, who observed conduction in a linen thread. Von Guericke also described the first machine for producing an electric charge in 1672. The machine consisted of a sulfur sphere turned by a crank. When a hand was held against the sphere, a charge was induced on the sphere. Conduction was rediscovered independently by Englishman Stephen Gray during the early 1700s. Gray also noted that some substances are good conductors while others are insulators [4].

Also during the early 1700s, Frenchman Charles Dufay observed that electric charges are of two kinds. He found that opposite kinds attract each other while similar kinds repel. Dufay called one kind vitreous and the other kind resinous.

American scientist Benjamin Franklin theorized that electricity is a kind of fluid. According to Franklin's theory, when two objects are rubbed together, electric fluid flows from one object to the other. The object that gains electric fluid acquires a vitreous charge, which Franklin called positive charge. The object that loses electric fluid acquires a resinous charge, which Franklin called negative charge.

Franklin demonstrated that lightning is a form of electricity. In 1752 he constructed a kite and flew it during a storm. When the string became wet enough to conduct, Franklin, who stood under a shed and held the string by a dry silk cord, put his hand near a metal key attached to the string. A spark jumped. Electric charge gathered by the kite had flowed down the wet string to the key and then jumped across an air gap to flow to the ground through Franklin's body. Franklin also showed that a Leyden jar, a device able to store electric charge, could be charged by touching it to the key when electric current was flowing down the string [4].

Around 1766 British chemist Joseph Priestley proved experimentally that the force between electric charges varies inversely with the square of the distance between the charges. Priestley also demonstrated that an electric charge distributes itself uniformly over the surface of a hollow metal sphere and that no charge and no electric field of force exist within such a sphere. French physicist Charles Augustin de Coulomb reinvented a torsion balance to measure accurately the force exerted by electric charges. With this apparatus he confirmed Priestley's observations and also showed that the force between two charges is proportional to the product of the individual charges.
In 1791 Italian biologist Luigi Galvani published the results of experiments that he had performed on the muscles of dead frogs. Galvani had found earlier that the muscles in a frog's leg would contract if he applied an electric current to them.

In the early history of components, after the invention of the three electrode tube in 1906, radio telegraphy became commercially viable. Special Tubes, transmitters and receivers were design and built with the designer of the equipment constructing all the necessary component parts [6].

The idea of using relays as switching circuits in a telephone exchange was by no means now it was first conceived in 1912 by G.A Betulander and N.G Palmgren of Sweden who also developed the crossbar selector. Although his name is less well known, Betularde is to the relay exchange what stronger is to the selector exchanger [1].

The idea of using the super conductive transition to switch a small resistance into and out of a circuit at will seems to have occurred at about the same time in the laboratories at Laiden and Toronto in 1935. Casimir-Jonker and de Haas (1935) developed an apparatus to detected the first trace of resistance in a super conducting specimen, the change of field external to the cryostat when the current decayed in a super conducting lead Solenoid around the specimen was used to restore it resistance and a resistance as small as 3×10 ohms produced a decay of current rapid enough to be detected [10].

At Toronto, Grayson Smith and Tarr (1935) used a moving-coil magnetometer inside the cryostat itself, consisting of fixed lead field coils and a moving copper coil. A short section of lead wire in series with the field coils acted as a super conducting switch and could be driven normal by means of a current in a copper Solenoid. The apparatus was used for measuring small persistent currents, again by observing their decay used in this way as a super conducting galvanometer, it was capable of detecting current as small as 10-4 amp in a circuit of self-inductance of $5\times10_{-4}$ Henry [3].

2.2 Review of Past/Reported works

The loose-handle quick break switch was invented by J.A Holmes in 1884 for this device he was granted British patent NO: 3256 of 1884, under the title: Improvement in or application to switches or circuit closes for electrical connecting apparatus [7].

From the McGraw Hill Dictionary of science and Technical Terms, a switch is defined as "automatic Cutout Fuse changing switch is a means of moving a circuit from one set of connection to another by means of automatic [1].

Power Cutout fuses are inclusive in electrical installation (home and office wiring). One of the known contributors to electricity was Benjamin Franklin who proved lighting is electrical rod in 1752. Another was George Ohm's Law (V=IR). And another was the development of Thomas Edison, he also establish the first power plant in 1881 [2].

2.3 Electronic Components

Electronic circuits consist of interconnections of electronic components. Components are classified into two categories—active or passive. Passive elements never supply more energy than they absorb; active elements can supply more energy than they absorb.

Passive components include resistors, capacitors, and inductors. Components considered active include batteries, generators, vacuum tubes, and transistors [9].

2.3.1 Passive Component:

Passive electronic components are those components of an electronic circuit that can function without any external power source and they are:

i. Capacitor: -

A capacitor is a passive electronic component consisting of a pair of conductors separated by a dielectric. When a voltage potential difference exists between the conductors, an electric field is present in the dielectric. This field stores energy and produces a mechanical force between wide, flat, parallel and narrowly separated conductors.

Uses of Capacitor: -

Capacitors are used as follow:-

- To filter out interference.
- To smoothen the output of power supplies
- They are used in resonant circuits in radio frequency equipment to select particular frequency from a signal with many frequencies.

They are also fixed and variable capable capacitors whose capacitance values vary from few Pico-farads (Pd) to micro-farad (μF). They are classified as polarized and non polarized capacitors. The polarized capacitors have polarity of plus (+) and minus (-) at the terminals. Polarized capacitors are classified into:

i. Electrolyte

ii. Tantanum

While known polarized capacitors are capacitor without polarity such as glass, ceramics and polyester etc.

ii. <u>Resistor:</u> -

A Resistor is a component that provides fixed and variable in ohms to operate in electrical built circuits. There are two types of resistor:

(a) Fixed Resistor

(b) Variable Resistor

(a) <u>Fixed Resistor:</u>-

A resistor is a two terminal electronic component that produces a voltage across it's terminal that is proportion to the electric current through it in accordance with Ohm's Law (V=IR). Resistor are element of electrical networks and electronic circuits and are very common in most electronic equipment practical resistors can be made of various compounds and films, as well as resistance wire (wire made of high resistivity alloy such as nikel and chrone).

The primary characteristics of a resistor are the resistance, the tolerance, maximum working voltage and the power rating. Other characteristics includes: Temperature Coefficient, noise and inductance. Less well known is critical resistance, the value below which power dissipation limits the maximum permitted current flow and above which the applied voltage. Critical resistance depends upon the materials constituting the resistor as well as it physical dimensions; it is determined by design.

Resistors can be integrated into hybrid and printed circuits, as well as integrated circuit. Size and position of leads (or terminal) are relevant to equipment designers; resistor must be physically large enough not to overheat when dissipating their power.

(a) **Variable Resistor:-**

A potentiometer is a variable resistor whose resistance value can be change by sliding it contact wiper. Its resistive element picks off the desired value. It has a terminal at each end's of it resistive element and the other third terminal is connected to the moveable wiper or slider.

Uses of Resistors

- Biasing
- Limit current
- Voltage divider

(a) Fixed Resistor (b) Variable Resistor

Figure: 2.2 Types of Resistors (symbols)

iii. Transformer/Inductors: -

An inductor provides a known amount of inductance in an AC circuit. It is made by winding some length of copper wire around a core. This core determines the inductor to produce an AC current.

Types of Inductors

- Air Core
- Iron Core
- Paper Core
- Transformer

Transformer:-

A Transformer transfer electricity energy from one or more primary circuits by means of electromagnetic induction. There is no electrical connection existing between any primary or input circuit and any secondary as output circuit and no change in frequency occur .in this circuit [].

Type of Transformer

- Audio frequency Transformer
- Radio frequency Transformer
- Power Transformer

Power Transformer:-

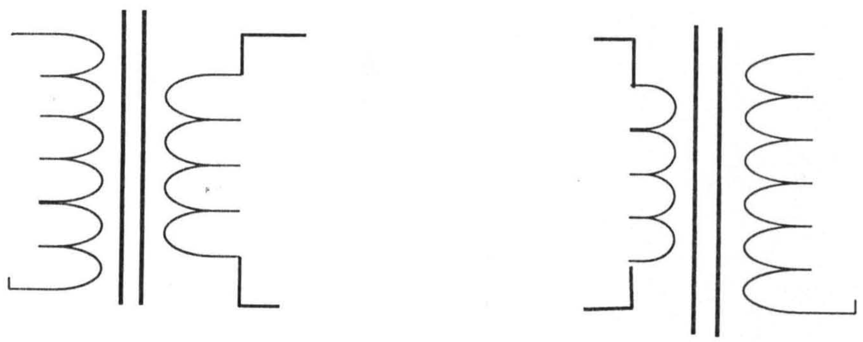
A power Transformer transform at 50-60 Hz AC line power to the voltage suitable for rectification to the desire regulated DC.

Types of Power Transformer

- Step-up Transformer
- Step-down Transformer

Step-up Transformer:- The number of turns in the secondary winding is twice the number of turns in the primary winding, so the voltage across the secondary windings is twice that of the primary winding, meaning that the output voltage is twice or more than the input voltage.

Step-down Transformer: - The number of turns in the primary winding is twice the number of turns in the secondary winding. The voltage across the primary windings is twice that of the secondary winding, meaning that the output voltage is half of the input voltage.



(a) Step-up Transformer (b) Step-down Transformer

Figure: 2.3 Types of power Transformer

iv. <u>Diode:</u> -

A diode is an electrical device that allow current to flow through it in one direction with far greater case than in the other. The most common kind of diode in modern circuit design is the semi-conductor diode, although other diode technologists exist. Semi-conductor diodes are symbolized in schematic diagrams in figure 2.4 below. The term "diode" is customarily reserved for small signal devices, that is current I ≤ 1A. The term rectifier is used for power devices that is current I > 1A [].

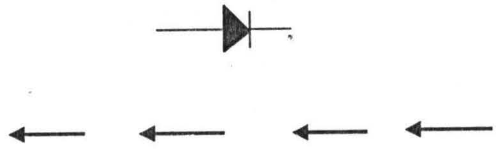
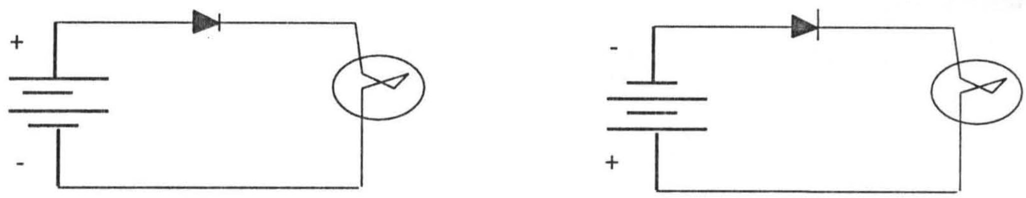


Figure: 2.4 Schematic symbol of semi-conductor diode:

(Arrow indicates the direction of electron current flow)

When placed in a simple battery-Lamp circuit, the diode will either allow or prevent current through the lamp depending on the polarity of the applied voltage. (figure: 2.4)



(a). (b)

Fig. 2.5 Diode Operation: (a) current flow is permitted; the diode is forward biased (b) current flow is prohibited; the diode is reversed biased

When the polarity of the battery is such that electrons are allowed to flow through the diode, the diode is said to be forward-biased. Conversely, when the battery is "backward" and the diode blocks current, the diode is said to be reversed-biased. A diode may be thought of as a switch; "closed" when forward-biased and "open" when reversed-biased. Oddly enough, the direction of the diode symbol's "arrowhead" points against the direction of electron flow. This is because the diode symbol was invented by engineers, who predominantly use conventional flow notation in their schematics, showing current as a flow of charge from the positive (+) side's of the voltage source to the negative (-). This convention holds true for all semi-conductor symbols processing "arrowheads" the arrow points in the permitted direction of conventional flow and against the permitted direction of electron flow.

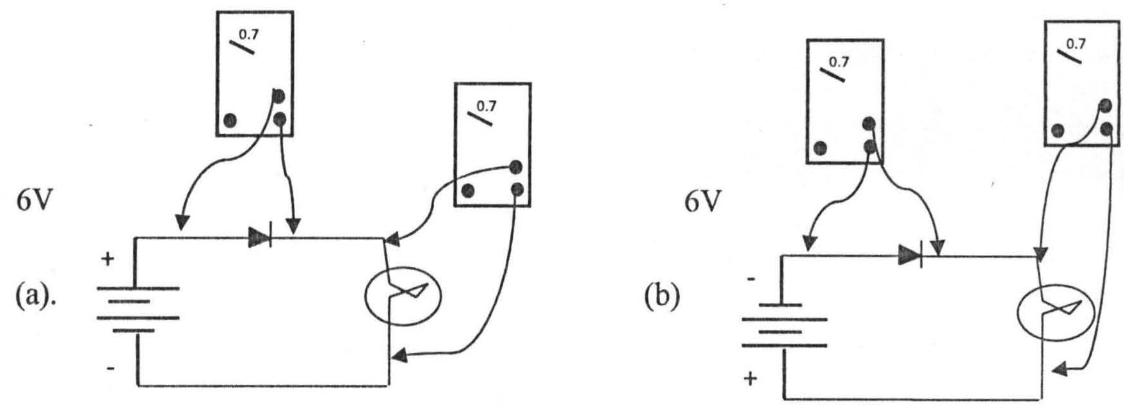
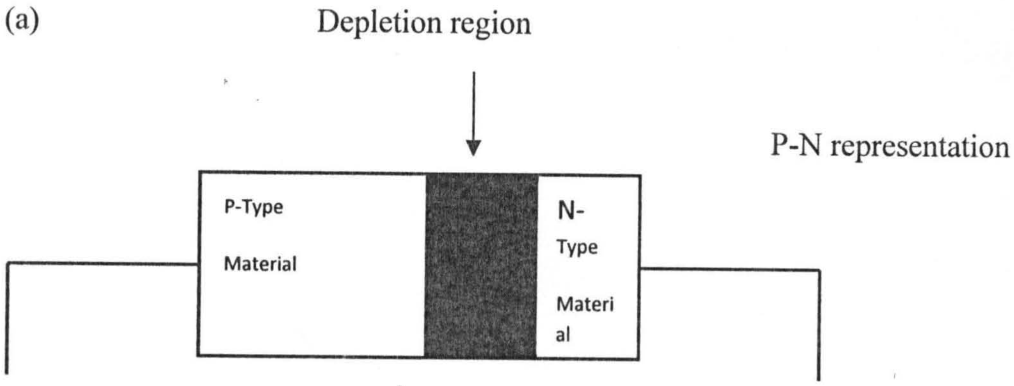


Figure: 2.6 Diode Circuit voltage measurements: (a) Forward biased (b) Reserve biased.

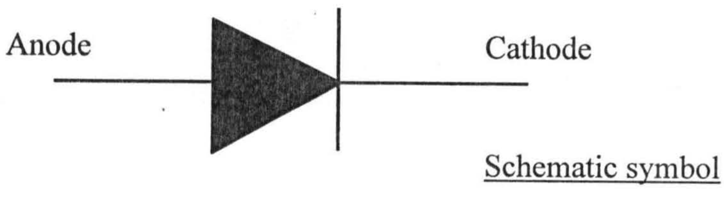
A forward-biased diode conducts current and drops a small voltage across it, leaving most of the battery voltage dropped across the lamp. If the battery polarity is reversed, the diode becomes reversed-biased and drops all of the battery voltage leaving none for the lamp. If we consider the diode to be a self-actuating switch (closed in the forward-biased mode and open in the reversed biased mode), this behavior makes sense. The most substantial difference is that the diode drops a lot more voltage when conducting than the average mechanical switch (0.7 volts versus tens of milli-volts).

This forward-biased voltage drop exhibited by the diode is due to the action of the depletion region formed by the P-N junction under the influence of an applied voltage. if no voltage is applied across a semi-conductor diode, a thin depletion region exists around the region of the P-N junction, preventing current flow. (figure 2.7 [a]) the depletion region exists around the region is almost devoid of available charge carriers and acts as an insulator:

(a)



(b)



(c)

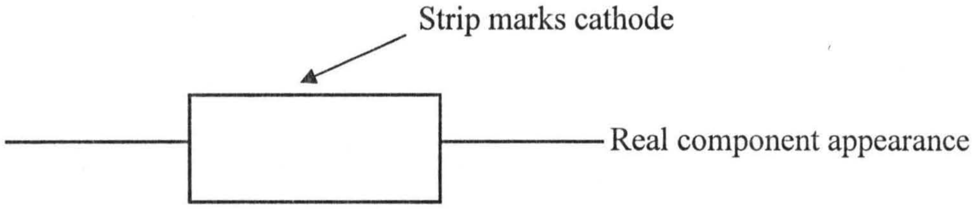


Fig. 2.7; Diode representations: PN Junction model, schematic symbol and physical part.

The schematic symbol of the diode is shown in the above figure (b) such that the anode (pointing end) corresponds to the P-Type semi-conductor at (a). The cathode bar, "non-pointing end" at (b) corresponds to the N-Type materials at (a). Also note that the cathode on the symbol [].

Type of Diode

- Rectification Diode
- Light Emitting Diode
- Photo Diode
- Zener Diode
- Signal Diode

Rectification Diode: - this is a diode capable of converting AC to DC. It can conduct one ampere (1A) or more and dissipated 1W or more power.

Electromechanical Devices

An electromechanical device is a passive electronic component that is compatible with electronic circuitry in size, weight and rating for mounting on circuit boards, Example of electromechanical devices are:

i. Relays

ii. Switches

iii. Solenoids

Relays: - A relay is an electrically operated switch. Electric current through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be ON or OFF so relays have two switch positions and they are double-throw (changeover) switches. Relays are classified as electromechanical (EM) and Solid State Relays (SSR). All electromechanical relays are identified by Output Current rating.

The most often used relays are Single Pole Single Throw (SPST) and Double Pole Double Throw (DPDT). Double Throw means that contacts are closed in one of two possible positions. The term "Normally Closed" (NC) and "Normally Open" (NO) refer to contact positions when the relay coils id de-energized or energized.

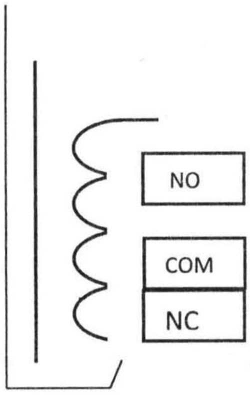


Figure: 2.8 The Schematic symbol of relay

i. **<u>Switches</u>**

Electromechanical switches for electronics are small mechanisms with electrical contact that permit manual opening or closing of circuit. Switches are the simplest and most basic of control devices. There are various types of switches such as :

i. Toggle Switch

ii. Push to make switch

2.4 Project Outline

This Project has five chapters.

- Chapter One: - Introduction to what a Cut-Out fuse is and the principle of it operation.
  - Motivation
  - Problem description

- Objectives of the work

- Chapter Two: - Literature Review
  - Details of relevant theory
  - Review of past/reported work
  - Brief introduction to the proposed work (design and construction of Automatic Phase Exchanger).
- Chapter Three: Discussion of research
  - This covers all the details of the methodology:- component calculation and how the values of the used component were determined,
- Chapter four: discussion of results
  - This chapter Analyzes how the Test, Result and Construction based on the method used in chapter three (3) were determine.
- Chapter Five: Conclusion and Recommendation
  - This chapter provides an objective evaluation/comparison of the research topic with related previous work.

CHAPTER THREE

DESIGN AND IMPLEMENTATION

This chapter discuss how the Main work was done e.g. solution approach, theory and how the circuit was designed.

3.1 Methodology:

The design and construction of Automatic Phase Exchanger was done using various steps and procedures to actualize and achieve the efficiency and reliability of the circuit design. Proper attention was given to these design parameters in order to generate the desired triggered signal.

The construction of the system is based on the method with available devices and other necessary components which perform different operations necessary for the overall of the system.

3.1.1 Procedure

A 220V/240Vac from the utility company was connected to 12Vac by the use of a step-down transformer. The 12Vac was rectified by a bridge diode which gives a pulsating 12Vdc. The capacitor was used to filter the pulsating 12Vdc to a pure 12Vdc. The pure 12Vdc obtain from the capacitor was then used to energize the coil in the relay which causes the contact to shift position. The Actuator unit is then connected to the load (lamp). Finally the entire circuit was soldered on a veroboard and cased in a transparent plastic and wooden.

3.2 Circuit design:

The circuit of the project was sectioned into two units. which are;

i- Power supply unit

ii- Actuator Unit

3.2.1 Power Supply Unit:

The power supply for this project is single 12V supply obtained from 240V/12V AC power transformer. The 12Volt was used for the operation of the system to produce the desired result, since the relay used requires 12Volt DC for the coil to function properly as directed by the manufacturer.

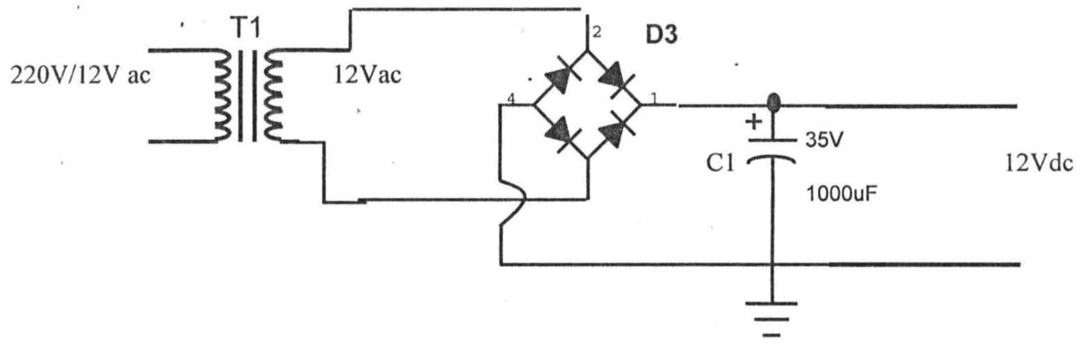


Figure 3.1 Power supply circuit

- **<u>Parts of a power supply</u>**

The power supply provides the proper voltage and current for electronic apparatus. The power supply for this project work consist of several stages, the stages are represented in the blocks as shown in Figure 3.2

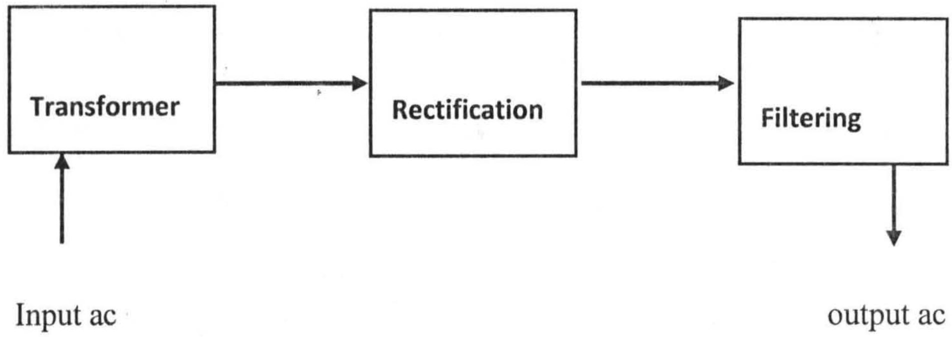


Figure: 3.2 Block diagram of power supply

The First stage (transformer), the ac encounters a transformer that steps the voltage down from 220V – 12V, since that is what the circuit requires.

Second stage (rectification), the 12Vac was rectified, so that it becomes pulsating dc with a frequency of 50 Hz. This was done by the use of four semiconductor diodes which form a bridge diode. The obtain full-wave rectification give a pulsating 12Vdc.

Third stage (filtering), the pulsating dc was filtered, or smoothed out, so that it becomes a continuous voltage having either positive or negative polarity with respect to ground. Here, a 1000uF 35V capacitor was employed to achieve this.

3.2.1 Actuator Unit

The actuator unit allows one circuit to switch a second circuit which can be completely separate from the first.

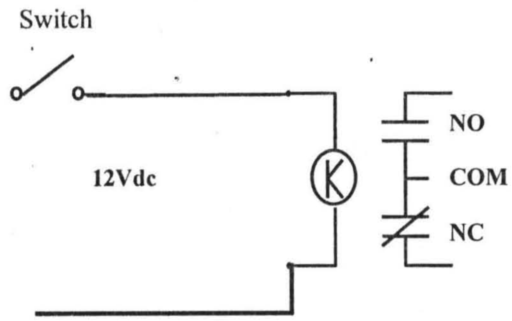


Figure.3.2 circuit symbol for relay

3.3 Components Selection:

The following Passive electronic components were used to build the circuit of the Automatic Phase Exchanger.

(1) Transformer

(2) Diode

(3) Capacitor

(4) Relay

3.3.1 Power Transformer Selection

Power transformers can be categorized as step-down or step-up. The output, or secondary, voltage of a step-down unit is lower than the input, or primary, voltage. The reverse is true for a step-up transformer.

- **Transformer Rating**

Transformers are rated according to output voltage and current. For a given unit, the volt-ampere capacity is often specified. This is the product of the voltage and current.

Design Analysis

The Transformer is selected to deliver at unity power factor.

Primary voltage, $Ep = 240V$

Secondary Voltage $Es = 12V$

Transformer Ratio $R_T = \frac{Ep}{Es}$

$$RT = \frac{240V}{12V}$$

$$= 20$$

And the AC and DC current (I_{AC} and I_{DC}) are obtained as follows:

AC current (I_{AC})= 500mA

DC current, I_{DC}

DC current, $I_{DC} = \frac{2\sqrt{2}}{\pi} \times IAC$

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

$$= 0.45A$$

$$= 450mA$$

The nature of power-supply filtering, to be discussed a bit later in this chapter, makes it necessary for the power-transformer VA rating to be greater than just the wattage needed by the load.

3.3.2 Diode Selection

Rectifier diodes are available in various sizes, intended for different purposes. Most rectifier diodes are made of silicon and are therefore known as silicon rectifiers. A few are fabricated from selenium, and are called selenium rectifiers. Two important features of a power-supply diode are the average forward current (Io) rating and the peak inverse voltage (PIV) rating. There are other specifications that engineers need to know when designing a specialized power supply, but in this project only Io and PIV was considered.

Figure 3.2A and 3.2B shows the input wave form of AC supply and the rectified output wave form respectively.

Design Analysis

Dc Voltage across the rectifier,

$V_{DC} = V_{AC}$

$12 \times \sqrt{2} = 16.97$ V

Peak inverse voltage,

$PIV = 2 \times V_{DC} = 33.94$ V

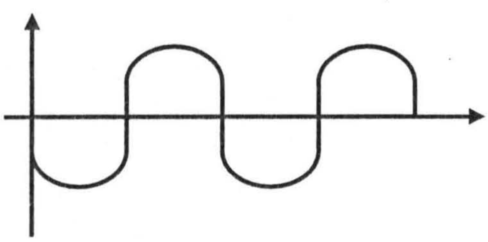


Figure: 3.2A input wave form of AC supply

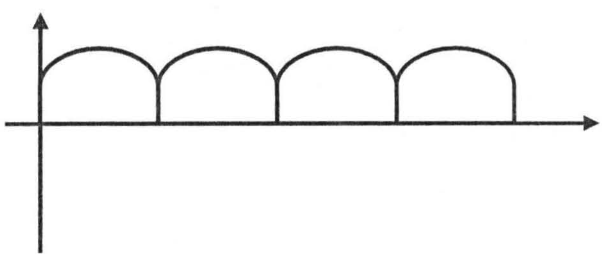


figure. 3.2B the rectified output wave form

Rectification is the conversion of alternating current i.e. AC-DC. In this projects work, a full bridge system of rectification was adopted with this method, there is no need for a center tapped power transformer.

3.3.3 Filter Selection

Electronic equipment doesn't like the pulsating dc that comes straight from a rectifier. The ripple in the waveform was smoothed out, so that pure, battery-like dc is supplied. The filter does this. The choice of smoothening capacitor was obtained from a supply frequency of 50HZ. The output waveform in figure 3.2A shows the converted AC before capacitor. A ripple voltage was removed through filtering or smoothening DC voltage by a capacitor.

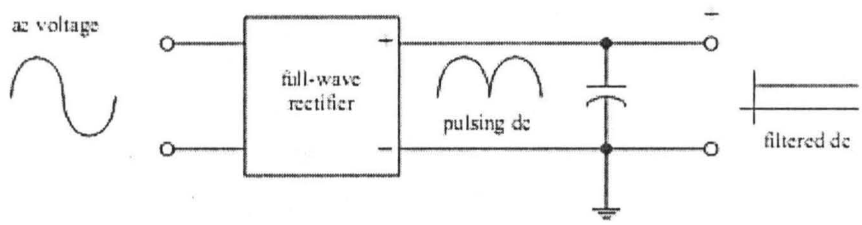


Figure: 3.3 Power supply filtering

The ripple Voltage is given by:

$$V_r = V_{pp} - V_{rms}$$

Where $V_{pp} = peak\ to\ peak\ voltage,$

$V_{rms} = secondary\ voltage\ (12V)$

$$V_r = 17 - 12$$

$=5V$

But $C = I_{DC}/2fV_r =$

$$= \frac{450x10^{-3}}{2\,x\,50\,x\,5}$$

$= 900uF$

(1000uF was used in this project since there is no 900uF capacitor)

Capacitor voltage;

$V\,c = 1.5\,x\,V_{DC}$

$= 1.5 \text{ x } 17 =$ NHM

$= 25.5V$

Hence, an electrolytic capacitor was selected for smoothening capacitor, since they fall in this range.

3.3.4 Relay Selection

A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts

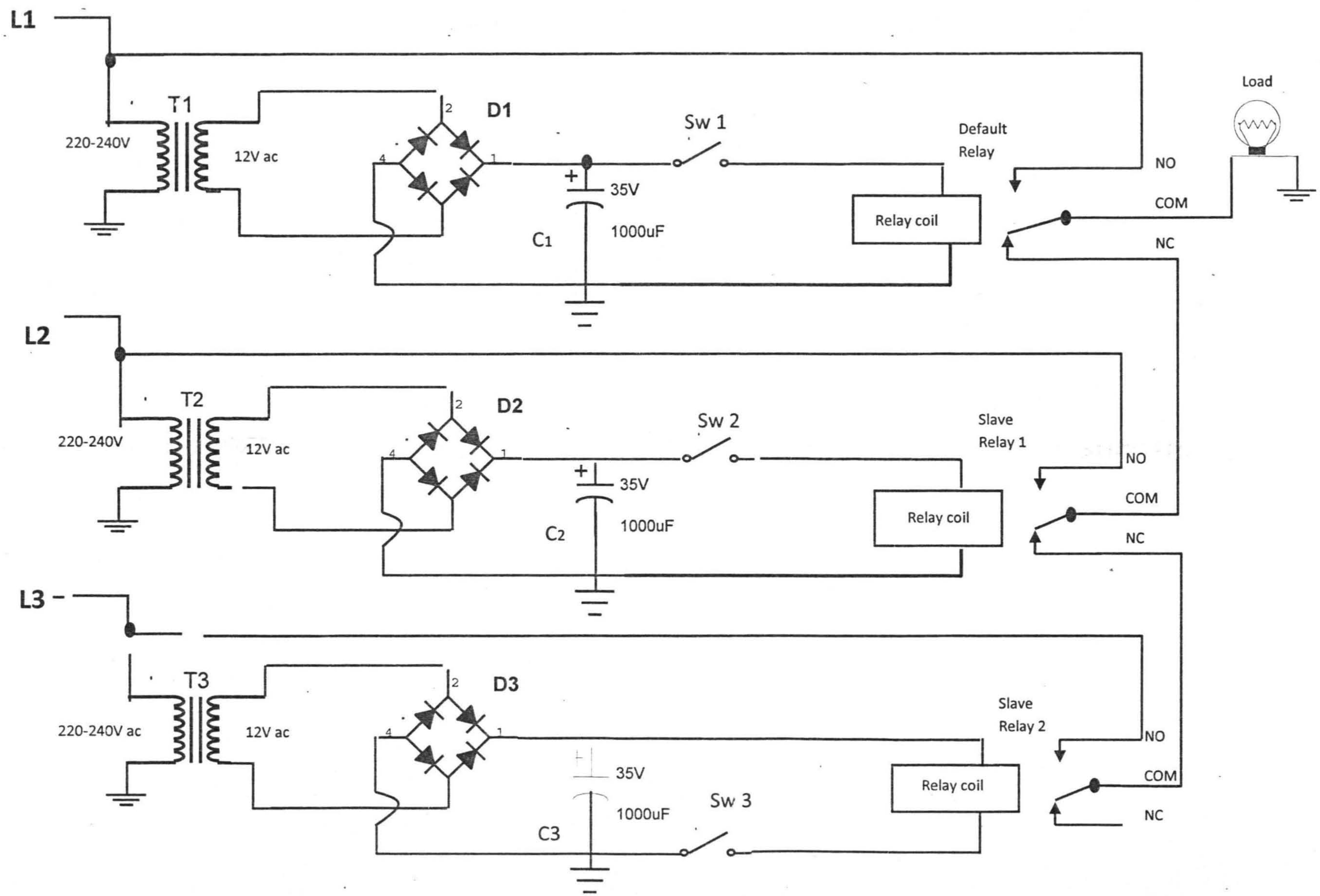
There is no electrical connection inside the relay between the two circuits, the link is magnetic and mechanical.

There are three AC relays with holding contact current of 30A and 220Vac-240Vac). They have a 12V DC operating voltage, 170 Ohms internal resistance, the resulting magnetic field attracts the armature and the consequent movement of the moveable contact either makes or breaks a connection with the fixed contact. If the set of contacts were closed when the relay was open de-energized, then the movement opens the contacts and breaks the connection, and verse versa. When the current to the coil is switched off, the armature is returned by a force approximately half as strong as the magnetic force, to its relaxed position. Usually this force is provided by a spring.

3.4 Circuit Configuration

T1, T2 and T3:	220-240V/12V Transformers.
D1, D2 and D3:	Bridge Diodes.
C1, C2 and C3:	1000uF 35V Capacitors.
SW1, SW2:	Shift Toggle Switch.
SW3:	Emergency Switch.
RL1, RL2 and RL3	12Vdc, 30A Relays

CIRCUIT DIAGRAM OF AUTOMATIC PHASE EXCHANGER



CHAPTER FOUR

RESULT, TEST AND DISCUSSION

This chapter discuss, the result and findings based on the methods describe in chapter 3.

4.1 Discussion of result

The discussion of the results is staged according with the mode of operation and in accordance with the methodology in chapter 3 of this project.

4.2 Mode of Operation

- Normal Mode
- Shift Mode
- Emergency Mode

4.2.1 Normal Mode:

In normal mode either of the 3 phases or all the phases i.e. the Red, Yellow and Blue phases is/are energized but only one among the 3 phases will be allowed to supply the load at a time to prevent short circuit. In Normal Mode the circuit functions in 3 different conditions. The conditions are as shown in the below Truth Tables;

Condition 1:

When all phases are energized (Red, Yellow and Blue phase)

Table 1.1: Normal Operation Mode

Line	Normally Open	Normally Close	Load
Line 1	1	1	1
Line 2	1	1	1
Line 3	1	1	1

In this condition all phases are energized but only the default phase will supply the load. This mode of operation is shown in figure 4.2

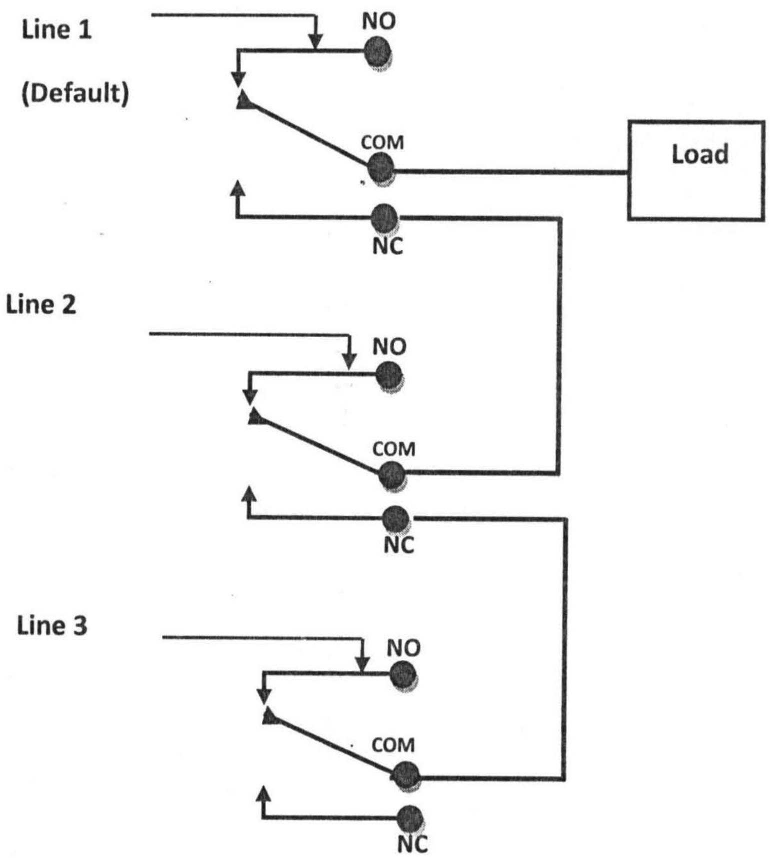


Figure 4.1 diagram of Automatic phase exchanger in Normal Mode

Condition 2:

when two phases are energized excluding the default line, Meaning the Normally Open of the Default phase is Off while the **Normally Open** of the second and the **Normally Open** of the third Phase are Energized, only the second phase will supply the load because the Normally Open and the **Common** of the slave relay (second) energized the **NC** and the **COM** of the Default relay while the relay is connected to the Load. The operation is shown in figure 4.2 below

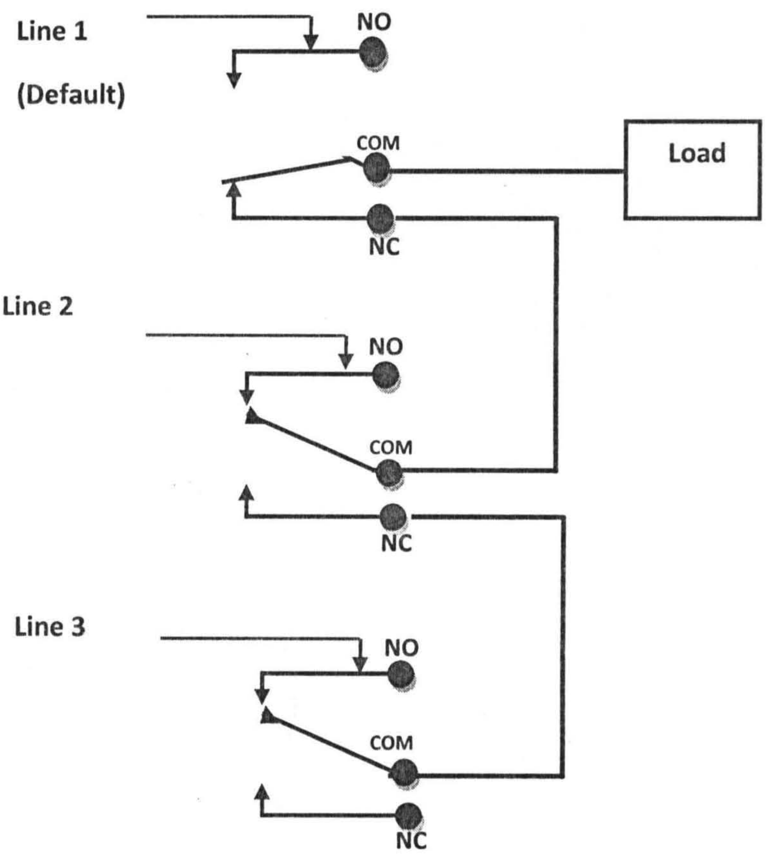


Figure 4.2 Diagram of 2 energized actuator excluding the default)

Condition 3:

When just one actuator is energized (only one Line 3 is ON) i.e. the other two actuator are de-energized (OFF), the third phase (Line 3) supply the second slave relay (Line 2) while the second slave relay energized the default relay. The default relay power then power the load. The operation is shown in fig. 4.3

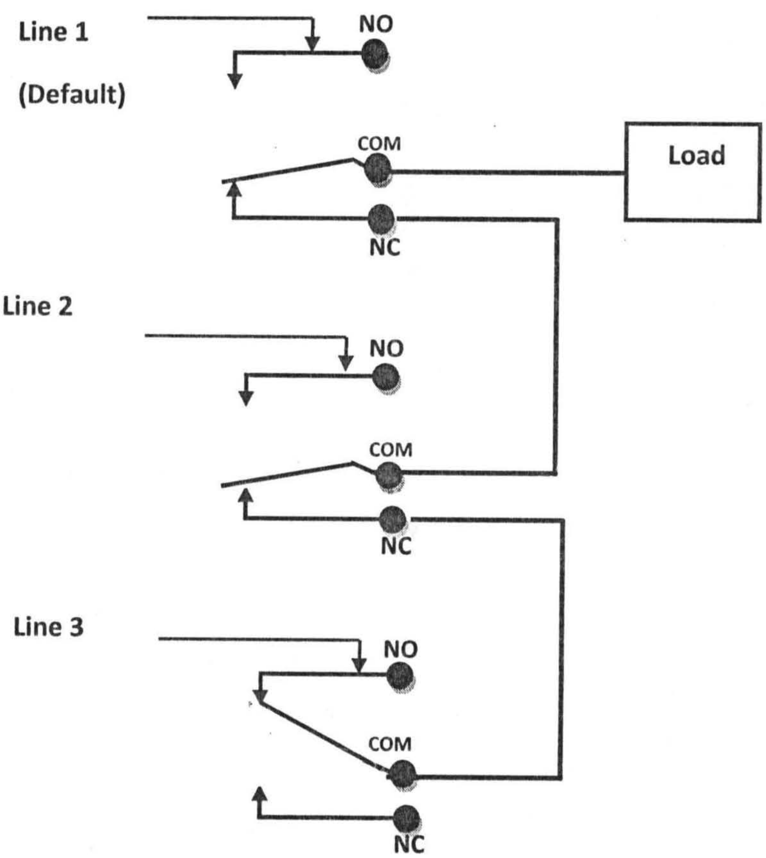


Figure: 4.3, Diagram of Automatic Phase Exchanger when Line 3 alone is energized

4.1.2 Shift Mode

This mode is applicable to Line 1 (Default line) and Line 2 alone. In the shift operation mode, when the phase has less than the required voltage (220-240V) in the any of this two lines the toggle switch is used to put the particular line OFF. Also, whenever the voltage comes up to 190V to 240V, it changes automatically back to the default, that is to say the circuit will go back to the Normal Operation Mode. Figure 4.3 shows the behavior of the actuator unit in this mode of operation. Immediately the toggle switch is put off as a result of low voltage the system select the either of the energized Line. The operations are show in Table 4.2 and 4.3 below

Table 4.2: Shift Operation Mode for Default Line

Line	Normally Open	Normally Close	Load
Line 1 (Default)	0	1	0
Line 2	1	1	1
Line 3	1	1	1

In this mode of operation only the Line 2 and Line 3 are ON, Line 1 is OFF.

Table 4.3: Shift Operation Mode when Line 2 is de-energized

Line	Normally Open	Normally Close	Load
Line 1 (Default)	1	1	1
Line 2	0	1	0
Line 3	1	1	1

In this mode of operation only the Line 1 and Line 3 are ON, Line 2 is OFF.

Table 4.4: Shift Operation Mode when Line 1and Line 2 is de-energized

Line	Normally Open	Normally Close	Load
Line 1 (Default)	0	1	0
Line 2	0	1	0
Line 3	1	1	1

In this mode of operation only Line 3 is ON, both Line 1 and Line 2 are OFF.

4.1.3 Emergency Mode

This mode of operation is used to prevent current from getting the load. It is been control by the user to de-energize all the actuators. The toggle switch is used to cut-off power from the house unit whenever there is a fault or a new electrical installation is to be made. This mode of operation is shown in Table 4.5.

Table 4.5: Truth Table showing Mode of Operation in Emergency Mode

Line	Normally Open	Normally Close	Load
Line 1 (Default)	0	0	0
Line 2	0	0	0
Line 3	0	0	0

In this mode of operation all the 3 Lines are put OFF.

4.2 Test and Construction

The construction of this project was made in stages. The soldering of the components and connection of the circuit coupled with the entire project casing was constructed on the vero-board a jack and socket plugged to the toggle switch for the operation.

This is where the fantasy of the main concept meets a physical reality. Here, the designer sees his work not just drafted or drawn but a finished product. The process of testing and implementation of some measuring equipments, tools and materials as mentioned below;

- Digital Multimeter
- Power Supply
- Lead
- Soldering Iron
- Lead Sucker
- Wire Cutter
- Bread Board
- Vero-Board

- **Digital Multimeter**

The digital multimeter basically was used to measure Voltage, Resistance, current, frequency and continuity test. The process of implementation of the design on the board requires the measurement of parameters like charges, continuity, current and resistivity value of the components.

- **Bread Board**

It is used temporary for the circuit testing with a tiny socket that allows the electronic component and connections to be inserted and removed without damage. The bread board is meant for pre-connections, testing of circuits and sub-circuits before the component are soldering on the Vero-Board.

- **Vero-Board**

This is a perforated board on which electronic components are permanently soldered and other connections are made.

4.3 Steps of Installation

Several steps were followed during the installation of the components in the circuit;

a. Circuit Positioning
b. Phase Connection
c. Plug Connection
d. Engine Switch Cable Connection
e. Power output to load

4.3.1 Circuit Positioning

The constructed circuit (Automatic Phase Exchanger) was house with case made of ply-wood and screwed to the wall in a ventilated area because the circuit has three transformers that produce heat when in operation. This will prevent it from burning.

4.3.2 Phase Connection

From the mains, three live and a neutral wire were connected to the input of the circuit appropriately, (i.e. three phases of power from utility source). This will connect the circuit to the load.

4.4 Testing and Interfacing

After all the integrated circuits and other components were fixed on the vero-board and the workability of each unit was ensured through testing, the following tests were carried out after permanent circuiting.

4.4.1 Continuity Test

The Multimeter was used to determine continuity between the holes on a breadboard before and after components terminals were inserted into holes on a plastic grid, metal spring clips underneath each hole connecting certain holes to others. A small piece of 30-gauge solid copper wire were inserted into the holes of the breadboard, to connect the meter to these spring clips so that continuity can be easily done. All terminals connected to the same port e.g. Vce and ground were confirmed.

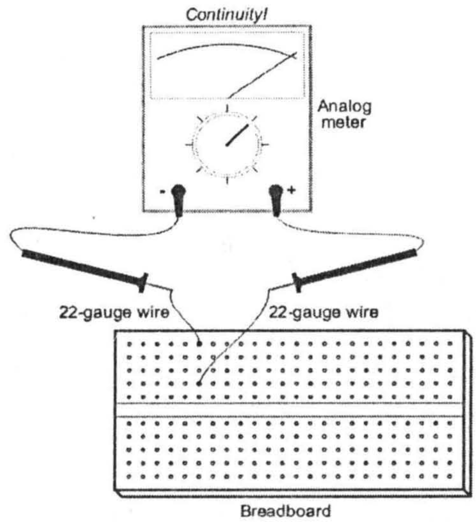


Figure 4.1: diagram of continuity test on breadboard

4.4.2 Performance Test

After casing the project, it was powered and the load was attached to it, during this process the multimeter was used to confirm the values to ensure that the desired output is realized. The operational performance of each individual unit was tested.

4.4.3 Packaging and Casing

A white plastic case was used to house the soldered work. The case is rectangular in shape with holes drilled behind for ventilation for the transformer. Also holes were bore for the 3 toggle switch and the lamp holder was attached to the case with screw. The casing was tight with screws for accessibility.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

With the automatic phase exchanger consumers of electricity will be free from hazard like electrocution and fire out-breaks that occur in the popular cutout fuse. Also, the stress of going to the cutout fusing board is eliminated since the device switch automatically from one power source to another when power outage occurs. Lastly, this project work shows and prove that relays can be applied in various ways, in circuit design, depending on how far the circuit builder can think.

5.2 Recommendation

The Automatic Phase Exchanger is recommended for both small and large building during Electrical Installation instead of the popularly known Cutout Fuse that requires an operator.

Micro Controller Chips should be applied in circuit design since they can be instructed to give the required values of component needed.

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