CHAPTER ONE

INTRODUCTION

As the growing population of human race widens the gulf between energy supply and energy demand, the imbalance in energy availability sent researchers into excavating for a way of settling this age long squabble. A lasting solution is vested on alternative use of the renewable energy source, a project that is yet to be widely applied. Hence, the continuation of the unsettled yearns for sufficient power. Consequently, the power lines are frequently over loaded resulting to a trip of power by the action of switch gears or by the load shading process undertaken by the distribution authorities.

Since it is crystal clear that some institutions such as health related institutions and some other delicate systems should not be allowed to suffer equally with their counterparts, Automatic Phase Selector is used to sustain energy consumption in the time of phase trip. The design of this circuit involves the use of automatic switches but the details of design varies from place to place, time to time and also depends on the type of load involved.

This project involves the use of transistor driven relays to affect the change of phase whenever the voltage condition becomes intolerable in the previous phase connected.

1.1 BACKGROUND

The intelligent phase selector is a system that is capable of comparing three phases and switching automatically to any of the three phases. The system consists of three main parts namely; the transformer, comparators (which is the brain of the system) and electrical switching device (relay).

The transformer used here is the step down type of transformer (it step down 240v to 12v) and these transformer is feed in with different phase voltage, rectified and smooth. Then fed in to a voltage regulator that has positive output. The regulator outputs were connected to comparators. Here the comparators are three in number. We call the comparators the brain of the system because these comparators are connected in a way that each of them will give out an output.

The relay in the system is where the output voltage is connected. In this project we even went as far as using pictures for illustration of some components.

1.2 AIMS/OBJECTIVES OF THE PROJECT

The analysis of this project cannot go without enumerating the goals meant to be achieved in the pursuit of the work. These objectives include:-

i. To develop a simple low cost device aimed at easing the prevalent burden faced by delicate offices, parastatals and institutions who need very low but constant power supply. Since supply is always on along the distribution lines that supply such sites, what pesters on the progress of work thereof is always the unwarranted trip of phases due to power usage from neighboring consumers. The automatic phase selector therefore, erases this setback form the face of progress of work in such offices.

ii. To stimulate the interest of upcoming students to take up research not only in their field of study “Electrical/Electronic Engineering” but also to extend their arms to other disciplines, thus enhancing the versatility of Electrical/Electronic Engineering.

iii. To create awareness that will stimulate the interest of fellow students who intend to take up research topic on automatic switch of any type.

1.3 RELEVANCE OF THE PROJECT

The issue of selecting or switching over manually is now a thing of the past. Nowadays we know that homes and offices enjoy steady power supply once the three phases are available (i.e. red yellow and blue phases). Is just a question of making a quick and automatic three phase selector?

1.4 SCOPE OF THE PROJECT

The scope of the project covers aspects like the features of automatic three phase selector, its applications, and its operations. Its advantages and its components. Finally, it covers the importance on the need of automatic three phase selector and contributions toward a greater sharing load balance and a better three phase power distribution and monitoring for domestics consumers.

1.5 LIMITATIONS

Owning to the nature of this project, the research centers and the resources were not easy to come by within the immediate environment. Some of the limitation encountered on the course of this project include financial and time constrains which did not really take much room for additional capacity beyond what is at hand.

1.6 TARGET BENEFICIARIES

This project will provide lasting solutions to the heavy losses incurred by commercial institution, industries, hospitals, airport etc caused by poor manual selector means and efficient switching facilities. It will also be of use in our household because poor selector of phase manually causes damage to our household equipment example electronics like television,radio,videoplayer etc and electrical appliances like refrigerator, air condition, fans just to mention but a few. Finally another target is to eliminate the loss of human life due to manual selection of the three phases.

1.7 SIGNIFICANCE OF STUDY

The significance of this project work cannot be overemphasized. This is because the number of lives that has being lost to the hand of interruption of power in health institutions and the like is not negligible. Delicate appliances have become the main victim of this artificial circumstance. The applicability of the outcome of this research work in several facets of human endeavor makes this work of real importance to humanity.

The use of the device produced from this research work would help to reduce human labor and hazard, going by the fact that many have been handicapped by electric shock because of the attempt they made to select another phase, and that the handicapped are helpless and cannot change phase.

1.8 ACHIEVEMENT OF THE CONSTRUCTION OF THE PROJECT

As long as electrical generation and construction is must in everyday activities, electrical power consumption is expected to be reliable and constant supply. Therefore, what we tend to achieve from this project is;

1. To have constant power supply.
2. To have quick operation i.e. phase selection
3. Reliable power supply
4. Easy operation
5. Avoidance of risk in doing manual changeover or switch

CHAPTER TWO

2.1 LITERATURE REWIEW

In this chapter we are looking in to the definition of “Automatic three phase selector’’, and what brought about the automatic phase selector. Also we will look at way of effecting the design and construction; its area of application and uses and also some of the important components in the device that make it carry out its operation successfully.

2.2 EFFECT OF POWER FAILURE

For the past 100 years, the utility’s job has been to keep the’ lights on.’ For today’s highly automated factories and processes, that is no longer sufficient. Even ¼ second voltage sag is sufficient to bring our modern machines to a screeching halt, resulting in hours of interrupted production and irrecoverable scrap. Yet it is interesting to note that most utilities are only required to record outages that last more than 1-5 minutes. So if factory is experiencing 10-12 momentary interruptions every year, costing millions of dollars in lost productivity, it is likely that the utility would represent that it was providing perfect power. This demonstrates a significant disconnect between the two positions, one that is unfortunately very commonly found. Thousands of facility-years of power monitoring at large industrial plants clearly demonstrates that, almost without exception, these plants experience anywhere from 8 to 24 power quality disturbances every year that are significant enough to impact plant operations. Most of the events are of short duration (1-6 cycles), corresponding to the clearing time of upstream utility protective equipment such as fuses, sectionalizers, breakers and reclosers [2, 3, 14]. It is important to understand the impact of such power disturbances on a plant's equipment and processes.

A process interruption caused by voltage sag may require a complete restart of the process, with hours of interrupted production. This can clearly cause substantial economic loss to the plant. However, most plants operate with contingencies built in for unscheduled downtime, and these inefficiencies are typically absorbed within this allowance. For plants with a substantial cost of downtime, voltage sag ride-through solutions can protect against process interruption. The market has been conditioned to correlate equipment failure, especially catastrophic failure, with voltage surges [17]. The use of multiple layers of surge suppressors provides clear evidence that the fear of equipment damage drives users to this 'apply and pray' strategy. Yet, voltage sags occur thousands of times more frequently than damaging voltage surges. In fact, even lightning strikes on the

power grid, thought to be a main culprit for voltage surges, have rarely been correlated with actually measured voltage surges, but have frequently been correlated with voltage sags [16]. The impact of voltage sags on equipment has not been studied in detail, and the interactions are poorly understood. This paper demonstrates that the very equipment at the heart of industrial automation—industrial drives, PLC's, robots, and motors—are also possibly most susceptible to damage from short duration voltage sags. This is a very counterintuitive result as one expects equipment to be robust under lower voltage conditions. In fact, some of the practices being followed to allow equipment controllers to ride-through voltage sags may exacerbate the potential for damage to equipment. Finally, the paper presents some techniques for minimizing the potential for damage to typical industrial automation equipment. The paper also points to a need for a standard that specifies equipment behavior under short duration voltage sags, a frequently encountered condition.

2.3 EQUIPMENT VOLTAGE SUSCEPTIBILITY

A modern automated factory is replete with voltage-sensitive devices and processes, among them computers, programmable logic controllers, sensors, servo drives, robots, CNCmachines, extruders, and aseptic processes. A common characteristic of all these devices is a dc supply that convert incoming single or three phase ac line voltage into a dc voltage that feeds the electronics and power electronics components[7], [8].A diode bridge is used to rectify the incoming voltage, while a capacitor is used to create a constant dc voltage. The impedance of the ac line, input transformers and input line filters (ac or dc) provide some level of isolation from the ac line. Under normal operation, the capacitor provides a filtered bus voltage for the load. The allowable ripple voltage and load current provide the equipment designer with guidance for choosing a specific capacitance value. Typical ripple voltage and input line current. One can see that such power supplies feature unity displacement factor, but poor harmonic factor, resulting in a poor overall power factor. This type of power supply is ubiquitous and is used in virtually all equipment found on the factory floor.

2.4 SYSTEM INTERACTIONS AND SOLUTIONS

In a typical manufacturing plant, the incoming power is distributed such that while there are several types of equipment and tools that are directly connected to the incoming three phase power, there is an even larger number of different controllers, sensors and power supplies that are connected to a single phase source derived from the incoming line-line or line neutral three phase voltage. As such, a normal manufacturing plant will have a mix of single and three phase dc power supplies as front-ends for the equipment in the plant. In addition, there will be a fairly large number of direct connected induction motors. Based on the sensitivity of typical equipment, many of the 40-50 power quality events that occur will cause process interruptions [14]. Failure of specific equipment will depend on the input stage designs, distribution of symmetrical and asymmetrical sags, and the random nature of the point on wave at end of sag. This makes it very difficult for any single manufacturer to systematically track equipment failure within the facility, and to correlate it with a specific power disturbance. Positive correlation can be obtained by tracking equipment failures as recorded by the equipment manufacturer. For some specific products that have been investigated (including PLCs, robots, drives and medical equipment), it seems to be clear that input stage failures, in particular diode failures and burnt out traces/fuses/wires, seem to represent the most significant reliability problem. This paper provides a Means of understanding such failures. Two approaches are possible to fix the problem. The first is based on designing the equipment to survive voltage sags. This may be distinct from the issue of having the equipment ride through voltage sag. As equipment specifications today do not include voltage sag recovery characteristics, it is no surprise that equipment remains unprotected. Developing a standard to address equipment behavior upon sag recovery is clearly the long-term solution to fix the problem. In the near-term, a retrofit solution is required that eliminates the voltage sag, or eliminates the current surge that occurs on voltage sag recovery. Voltage sag correctors are available commercially [15] that allow equipment rated at 250 VA to 2,000 kVA to ride through voltage sags. While these devices mainly target process ride-through, they clearly protect the equipment from the voltage sag recovery transient, and eliminate the dangerous current surge. Power supply in Nigeria and most developing countries of the world is anything but stable. This has adverse effects on the consumers of the electricity and the equipments that are operated from the mains sources of electricity supply in these parts of the world. In this paper, we provide an automatic switching mechanism that transfers the consumer loads to another phase in the case of power failure in the other phases. It automatically detects when power has been restored to the phases. This mechanism has been tested and we recorded a great result. It thus holds an important key in the provision of a continuous power supply through a near seamless switching between the mains supply and the three phases.

Electricity (energy), which plays a major role in economic development of a nation, forms the basis of this study, with interests in human, infrastructural and economic development. In most developing and underdeveloped parts of the world, the supply of electricity for industrial, commercial and domestic use is highly unstable. This gives rise to the frequent use of alternative sources of power supply to meet up with the energy demands. The introduction of these alternative sources of supply brings forth the challenge of switching smoothly and timely between the mains supply and the alternative sources whenever there is a failure on the mains source. There is also the need to reduce drudgery from switching between the two sources on the human side. Solving these challenges forms the focus of this work. The Automatic three phase selector automatically switches over to the alternative phases when there is a power outage. The Automatic three phase selector is a device that links the load and the three phases and relay switches. This enables the use of either the remaining phases when there is outage on the mains source. This can either come in with three phase or single phase. This device maintains constant power supply to the load by automatically activating the phases when there is need. Since the user might not always be in need of the generator, provision has been made to prevent the generator from starting should an outage occur. We can't go on and on to emphasize the importance of power supply to our home and industries, but it is important to mention that the outage of power supply can bring discomfort in our homes and loss of revenue due to down time in the industries. Thus Tony Rudkin, the author of 'upgraded signal source with improved performance and reliability', states that the cost and the depreciation associated with breakdown vary from one application to the other, and in some cases, the user has little choice but to ensure that a stand-by unit is available to take over on event of failure of primary system. Also in his book, he went further to say that the depreciation caused by such instability reduces efficiency of the organization and leads to a great deal of frustration. Sequel to the rate at which more sophisticated electrical/electronic gadgets are being procured and installed in our homes, hospitals and business premises, there is a justifiable need for a faster and more reliable change-over system in an event of power outage. Because of the study of the problems cause by phases this lead to the invention of a switching device called the "automatic three phase's selector"

BACKGROUND OF THE AUTOMATIC THREE PHASE SELECTOR

The intelligent automatic three phase selector is known to be a device or electrical circuit capable of comparing three phases and switching over of the phases automatically. The use of the automatic three phase selector did not just start up so easily. In the earlier days consumers of electric power always use manual method to operate these phases. Without knowing if there is high voltage on the supply on the other phases. Then there came for the need of automatic phase selector of the phases. In other that this selecting or switching from one phase to another might be done automatically and quickly, an electrical device was designed and constructed to do the work quickly and reliably. The device became known as an "Automatic three phase selector". It is also regarded as an "intelligent phase selector" because it compares input or phase voltage and selects the one with the optimum voltage value for supply and can also switch over to another phase automatically if the present phase goes off.

According to Muhammad Ajman .P.(2007). "He talked about the three phase application saying, a proper rating fuse needs to be used in the input lines (Red Yellow Blue) of each phase." [10]

CHAPTER THREE

3.0 METHODOLOGY

This work was achieved using many design approach, which include all the step used designing my project such as soldering, connection of components, testing for continuity of the various components. The designing of this circuit will be accomplished by a constant and detailed study of the constituent components. This involved the study of their characteristics in isolation, and when connected together with some other components. A rough design was always made with some theoretical backup. Those designs were implemented and tested using project boards to first consult the prototype circuits

3.1 INFORMATION GATHERING

Much information was gathered from many people which include my lectures and my supervisor whom I consulted for explanation prior to choosing the automatic three phase selector. Most of the in formations gathered are from the following sources; technologist and internet.

TECHNOLOGIST: They advised me on a particular component to use and with the help of their advice which prompt me to choose the most durable components that will fit in the latest design of the automatic three phase selector. Each block that works was transferred to the Vero board where it was finally soldered in position.

INTERNET: Here I was educated much on the current and modern automatic phase selector available in the market. The internet was visited for circuit ideas where problems were encountered and the necessary adjustments made on paper and then constructed on the projects board. These are the primary source of my information about this project. I.e. the material used in designing and configuring of the automatic three phase selector.

3.2 WAYS OF EFFECTING THE DESIGN AND CONSTRIUCTION OF AN AUTOMATIC THREE PHASE SELECTOR

The prominent ones include;

1. Manual control
2. Sequential logic control
3. Micro processor control
4. Comparator control(operational amplifier LM 741)

3.2.1 PHASE SELECTION BY MANUAL CONTROL

In the past the regular practice has been to manually select the required phase in a three phase system with the help of a cut off (an electrical connector devices).

This is used by appropriately interconnecting end and selecting between the phases by manually plugging in to premeasured or detected voltage. This is known as the convectional approach to phase selection.

Limitations of manual control selection

1. It is strenuous to operate.
2. It causes device to damage due to manual operation.
3. It can cause fire outbreak.
4. It can make a lot of noise during the changeover.
5. It causes wear and tear during manual changing of the three phase leading to more frequent maintenance.

3.2.2 PHASE SELECTION BY SEQUENTIAL LOGIC CONTROL

In the sequential logic control of use to effect the detection and control of the phase voltage whereas the measurement can be done manually or equally automated by the same sequential circuit. This approach more often than not involving an appreciable level of both automatic and manual control. Hence it is more efficient than just the manual control.

3.2.3 PHASE SELECTION BY MICROPROCESSOR CONTROL

In the microprocessor based control, a central processing unit (CPU) which uses implanted software and stored memory (random access memory (RAM) read only me (ROM) is used to effect control. There are two aspects of the microprocessor control, they are;

1. Micro controller based control

2. Computer based control

3.2.4. PHASE SELECTION BY COMPARATOR CONTROL

A comparator is an operational amplifier circuit without negative feedback and takes the advantage of very high open loop voltage gain of op amp. A comparator has two input voltage (non-inverting and inverting) and one output voltage. Generally a comparators circuit consists of two input terminals and one output terminals. A signal at the output depends on the voltage of the input terminals. The comparators used in my project are the LM741 IC. The comparator circuit has the following two characteristics namely;

1. It is operated on a non linear mode
2. It uses no feedback so that the voltage gain is equal to the open loop voltage (A_{OL}) of OP-amp.

CHAPTER 4

4.0 SYSTEM DESIGN ANALYSIS

This chapter gives full detail design of the comprehensive project.

4.1. COMPONENTS USED IN THE DESIGN AND CONSTRUCTION OF THE AUTOMATIC THREE PHASE SELECTOR

Some important components of the automatic three phase selector are included below;

1. Transformer (step down transformer 12V)
2. Diodes –IN4007
3. Zener diode -5.1V
4. Capacitor-1000microF, 35V

   -470microF, 12V
5. Operational amplifier (LM 741)
6. Resistors- 3.3k, 10k
7. Potentiometer (variable resistor)-10k
8. Relay switches 12V, 400Ω

4.2. THE DESIGN TOPOLOGY

This is a block and line diagram that summarizes the actual work done. It consists of 4 blocks in each stage of the automatic three phase selector.

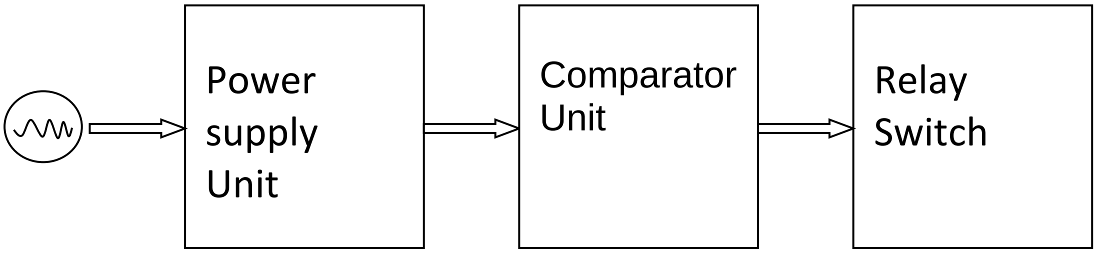

Fig 1 Block diagram showing the various stages of the automatic phase selector.

4.2.1 THE POWER SUPPLY BLOCK

Absolutely all the electronics equipment makes use of the DC voltage from either a battery or converted from an energy source such as the AC power line, the solar energy panels the thermal energy converted (thermocouple) and others. Here the power supply is a constituent block of the device. It can be regarded as the driving block since the operation of every other block absolutely lies on its output.

There are many types of power supply. Most are designed to convert high voltage AC mains electricity to a suitable low voltage supply for electronic circuits and other devices. It is made up of some sub blocks which includes: the step down (electromagnetic reduction of the input ac source) block, the rectifier (ac to dc converter) block, and the smoothening block.

For example a 5V regulated supply:

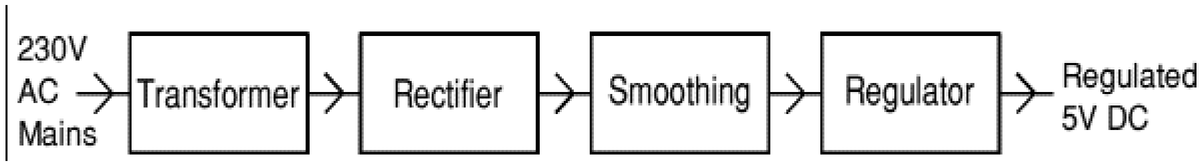

Fig 2 Block diagram of power supply

Each of the blocks is described in more detail below:

- Transformer - steps down high voltage AC mains to low voltage AC.
- Rectifier - converts AC to DC, but the DC output is varying.
- Smoothing - smooth the DC from varying greatly to a small ripple.
- Regulator - eliminates ripple by setting DC output to a fixed voltage.

Power supplies made from these blocks are described below with a circuit diagram and a graph of their output:

a) Transformer only

b) Transformer + Rectifier

c) Transformer + Rectifier + Smoothing

d) Transformer + Rectifier + Smoothing + Regulator

a) Transformer only

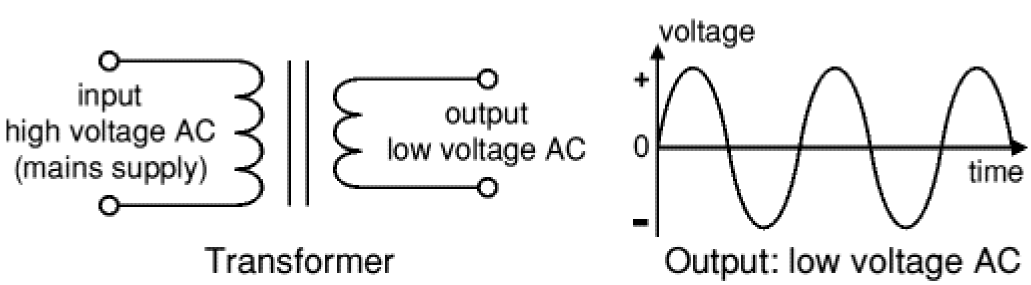

Fig 3

The **low voltage AC** output is suitable for lamps, heaters and special AC motors. It is **not** suitable for electronic circuits unless they include a rectifier and a smoothing capacitor.

b) Transformer + Rectifier

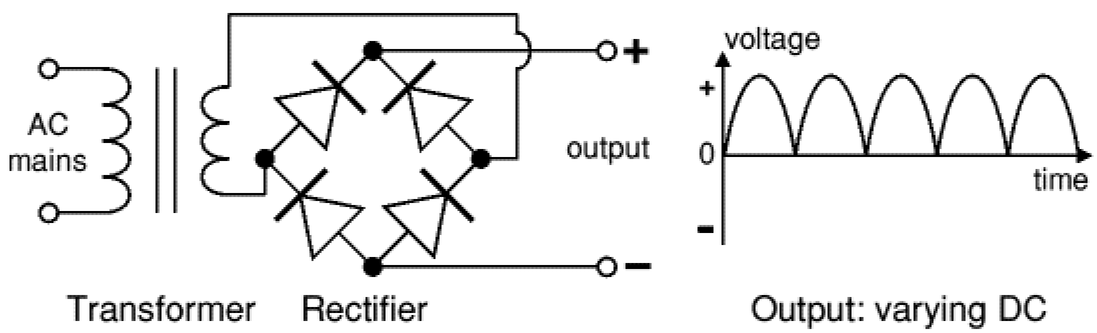

Fig 4

The **varying DC** output is suitable for lamps, heaters and standard motors. It is **not** suitable for electronic circuits unless they include a smoothing capacitor.

C) Transformer + Rectifier + Smoothing

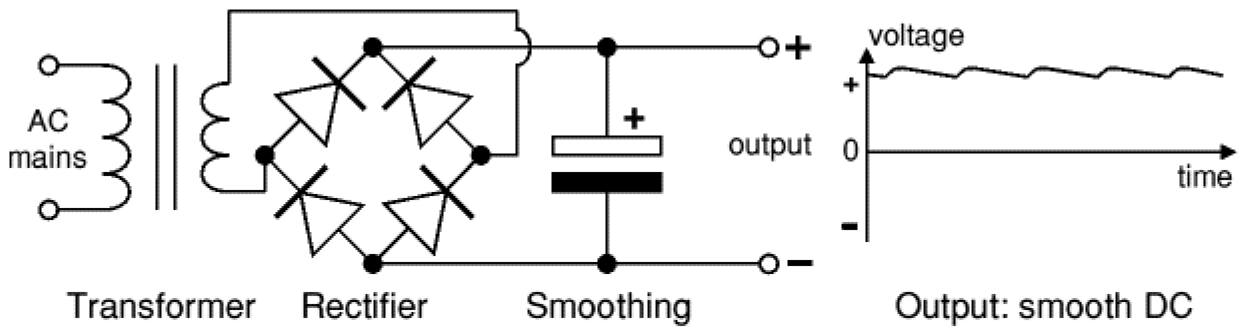

Fig 5

The **smooth DC** output has a small ripple. It is suitable for most electronic circuits.

d) Transformer + Rectifier + Smoothing + Regulator

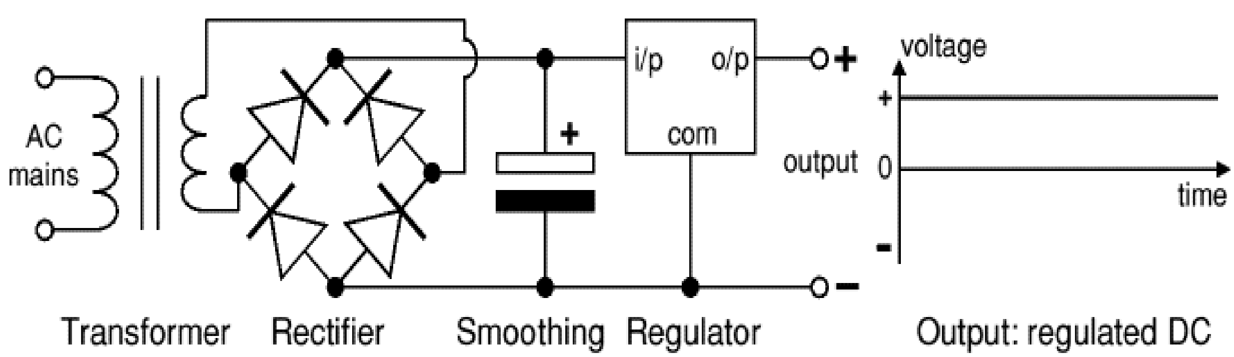

Fig 6

The **regulated DC** output is very smooth with no ripple. It is suitable for all electronic circuits.

1. **THE STEP DOWN BLOCK**

Under the step down block it consists of transformer. Here transformer is a static (or stationary) piece of apparatus by means of which electric power in one circuit is transformed in to electric power of the same frequency in another circuit. A transformer is also a device consisting of two closely coupled coils (called primary and secondary). An AC voltage applied to the primary appears across the secondary, with a voltage multiplication proportional to the turn’s ratio of the transformer and a current multiplication inversely proportional to the turn’s ratio.

Transformers are quite efficient (output power is very nearly equal to input power); thus a step-up transformer gives higher voltage at lower current whereas a step-down transformer gives a lower voltage at a higher currents.

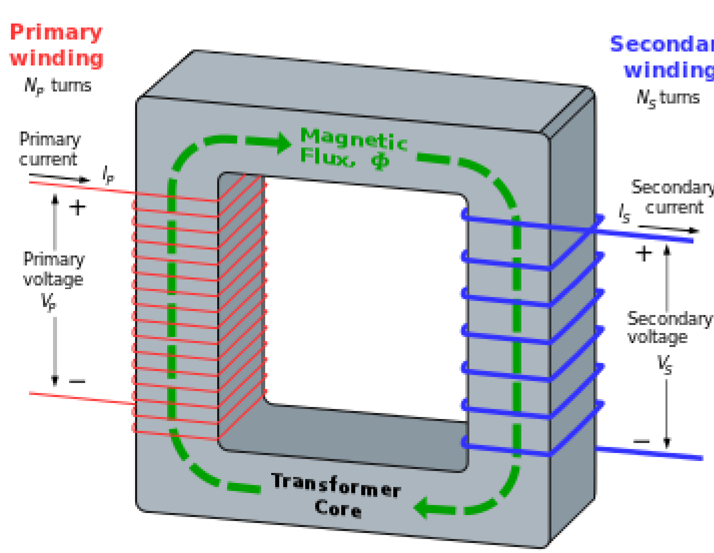

Fig 7 transformer windings

TWO IMPORTANTS OF TRANSFORMER IN AN ELCTRONICS INSTRUMENTS

i. The change the AC line voltage to a useful and lower value that can be used by the circuit.

ii. They isolate the electronic device from actual connection to the power line, because the windings of a transformer are electrically insulated from each other.

In step down transformer, the parameter is selected to be capable of meeting the load current sees a major load of the relay excitation coil, they should be capable of supplying up to the corking voltage of the relay as well as the relay current. A 220v: 18v, 500MA transformer satisfies these requirements. Because of the unavailability of a transformer of these parameters a 220v: 9v, centre tapped transformer is used instead, but its full span secondary voltage is used given a score of 18v at the secondary side of its winding.

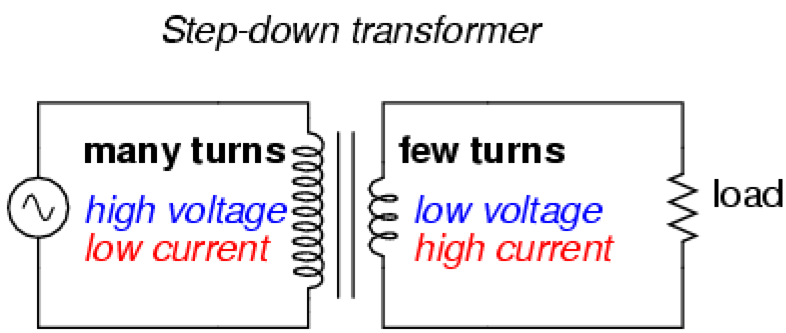

Fig 8 The transformer schematic

THE TRANSFORMER SPECIFICATIONS

In this project an 18Vac was used to step-down the 220Vac to 18Vac.

THE DESIGN CALCULATION

The transform input voltage (voltage in the primary winding) V_p = 220Vac

The transformer output voltage (voltage in the secondary winding) V_s=18Vac

The transformer primary current (current in the primary winding) I_p =200MA = 0.2 A.

The transformer secondary current (current in the secondary winding) I_s=unknown.

From the expression given below,

$$\frac{Vp}{Vs} = \frac{Is}{Ip}$$

Where VP = 220V

Vs = 18V

Ip = 0.2A

Is = ?

Therefore, $I_s = \frac{Vp \times Ip}{Vs}$

$I_s = \frac{220 \times 0.2}{18} = \frac{44}{18} = 2.44A$

Therefore, the transformer secondary current I_s=2.44A

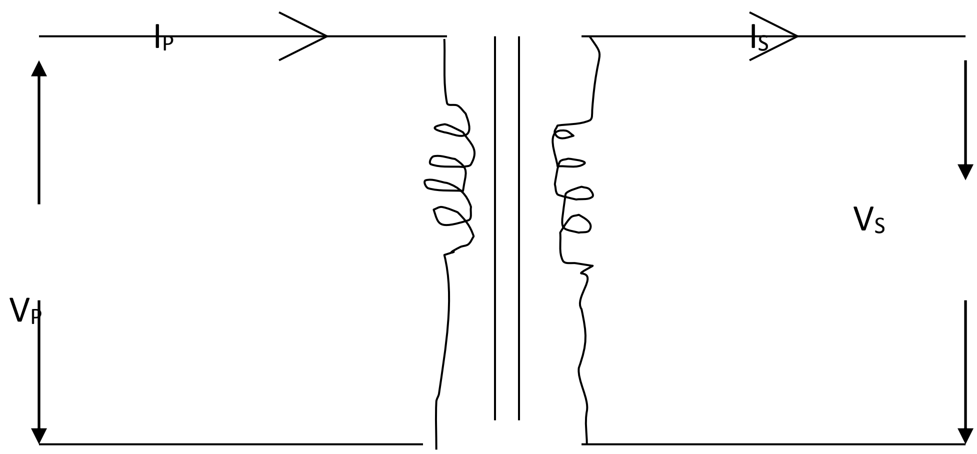

Fig 9 transformer circuit

From this analysis, the automatic phase selector circuit is designed to allow maximum amperage of 2.44A. This is the current of the sensing or control circuit circuit.

2. THE RECTIFIER BLOCK

The rectifier block is made up of four IN4001 diode connected in the bridge form. The operation of the bridge rectifier is simple to understand by visualizing the operation of the rectifier for the two half- cycles of the as wave form separately. The rectification circuit commonly called the converter is a circuit which employs one or more diodes to covert AC voltage into pulsating DC voltage. In my design the Full-wave bridge circuit was used because of its ability to produce a different reference voltage from the ac reference voltage. In other words it isolates the ac circuit completely from the dc circuit. The bridge rectifier is also less liable to many ripples which is the quantity that judges the genuine of the dc produced.

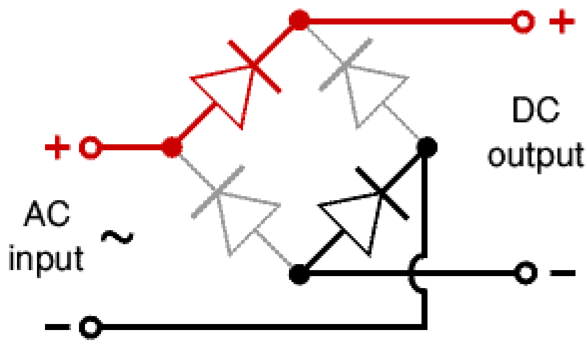

Fig 10 Circuit symbol for bridge rectifier

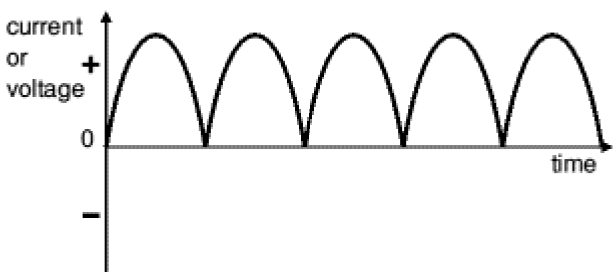

Fig 11 Output: full-wave varying DC

Current Flow in the Bridge Rectifier

For both positive and negative swings of the transformer, there is a forward path through the diode bridge. Both conduction paths cause current to flow in the same direction through the load resistor, accomplishing full-wave rectification.

While one set of diodes is forward biased, the other set is reverse biased and effectively eliminated from the circuit.

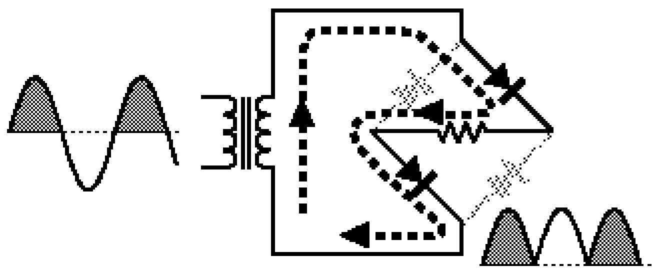

Fig12 (a) Positive swing of rectification

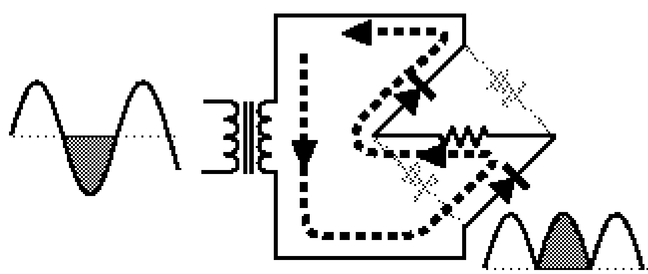

Fig 12 (b) Negative swing of rectification

A good number of electronics circuit requires the use of both positive dc source and negative dc source that are referenced at a common ground.

For the sake of this work the full wave bridge rectifier that supplies only a positive dc voltage and its reference is always referred to as the converted dc voltage.

DESIGN CALCULATIONS

The maximum instantaneous voltage between the terminals of the rectifier circuit is:

V_{max} = Vrms **x** $\sqrt{2}$

V_{max} = 18 x 1.4142= 25.46V

This is the magnitude of the summit lf the ac voltage wave form usually called the peak to peak voltage, which the desired circuit voltage is expected to swing. For this case it is from -25.46V to 25.46V.

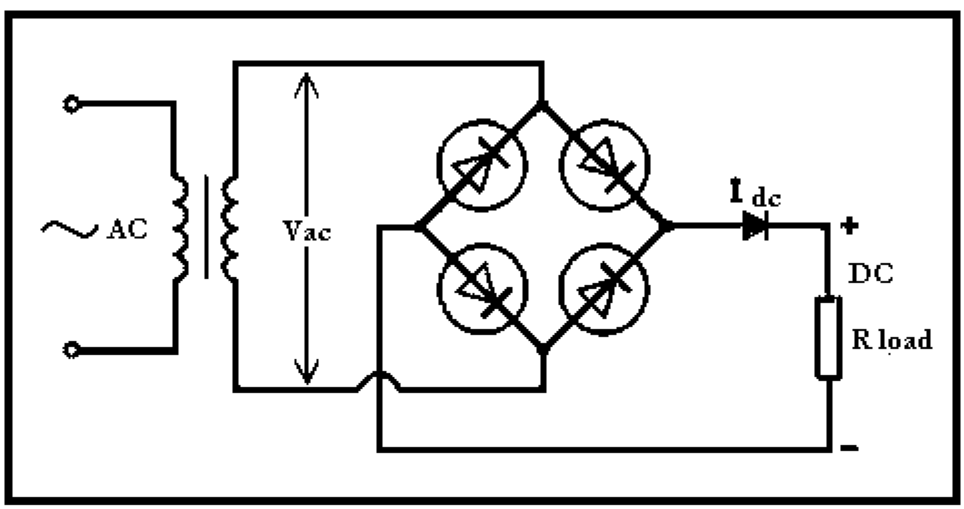

Fig 13, The full wave bridge rectifier .

From the above circuit,

d.c output voltage,V_{dc}= I_{dc}× R_L

where I_{dc}= dc output current(average current)

R_L=load resistance

In full wave bridge rectifiers, $\mathrm{Idc} = \frac{2\ \mathrm{Vmax}}{\pi\ \mathrm{Rl}}$

Therefore, $V_{dc} = I_{dc} \times R_L = \frac{2\ \mathrm{Vmax}}{\pi\ \mathrm{RL}} \times R_L = \frac{2\ \mathrm{Vmax}}{\pi}$

Finally our

$V_{dc} = \frac{2\ \mathrm{Vmax}}{\pi}$ (for a 2 – pulse, full wave, bridge ac to dc converter).

Where π=3.142

$V_{dc} = \frac{2\ \mathrm{Vmax}}{\pi}$

$V_{dc} = \frac{2\ \mathrm{Vmax}}{3.142}$

V_{dc} = o.636V_{max}.

It should be noted that the peak inverse voltage (PIV) of the rectifying elements (diode) should be greater than the maximum voltage, V_{max}. Since V_{max} is already calculated to be 25.46V. Therefore the peak inverse voltage is twice the maximum voltage across the secondary winding.

Mathematically, PIV=2 V_{max}= 2 × 25.46= 50.92volts

This value of PIV monitors the selection of the 4 diodes with which to form a bridge rectifier. In this case, the diodes to be selected must be capable of withstanding a potential stress equal to the peak inverse voltage.

The IN4001 is suitable for this application as indicated in the fair child table of data lf diode rectifiers below.

Item	Device No	PIV	I_R@ V_R UA_{max}	V_{max}	V_f@I_f	V_{max}	V_{fm}@I_O
1	IN4001	50	10	1.1	@1.0	1.6	@1.0
2	IN4002	100	10	1.1	@1.0	1.6	@1.0
3	IN4003	200	10	1.1	@1.0	1.6	@1.0
4	IN4004	400	10	1.1	@1.0	1.6	@1.0

Any of the four types of rectifier can work well but the IN4001is much lower than others and operates within the proximity of our design specification.

NB-consider the operating voltage of the dc relay.

3. THE SMOOOTHENING BLOCK

Here the smoothening block is also called the filter block or the filter circuit. The main function of the filter circuit is to minimize the ripple content of the bridge rectifier output. This is necessary because the absence of a filter will eventually result in distortion of signals hence the circuit may not work properly as there may occur a vibration of the relays when they are already switched on.

Its operation depends on the property of a capacitor to charge up during the conducting half-cycle and to discharge (deliver energy) during the non conducting half-cycle. Put differently, a capacitor opposes any change in voltage; it tends to smoothen out or filter out the voltage pulsations (or ripples). Hence the name "filter" given to power supply shunt capacitors.

Although the conventional and bridge full-wave rectifier circuits effectively converts the ac signals that have zero average, or dc value to a signal with a non zero average voltage, either rectifier output is still an oscillating wave form. Rather than provide a smooth, constant voltage, the full-wave rectifier generates a sequence of sinusoidal pulses at a frequency double that of original ac signal.

The ripple that is, the fluctuation about the mean voltage that is characteristic of these rectifier circuits – is undesirable since one desires a true dc supply. A simple yet effective means of eliminating most of the ripples (AC components) associated with the output of the ripple that preserves the dc component of the load voltage. A low-pass filter that preserves the dc component of the rectified voltage while filtering out components at frequencies at or above choice to remove the ripple component from the rectified voltage. In this case of rectifier circuit, the signal wave form to be rectified is 50Hz, 220v rms voltage.

The ripple frequency is therefore $F_{ripple} = 2 \times 50 = 100$Hz.

The relationship above is equivocal to ensuring small ripple through making the time constant for discharge much longer than the time between recharge. The diagram given below shows the original rectifier output and the out of ripple filter.

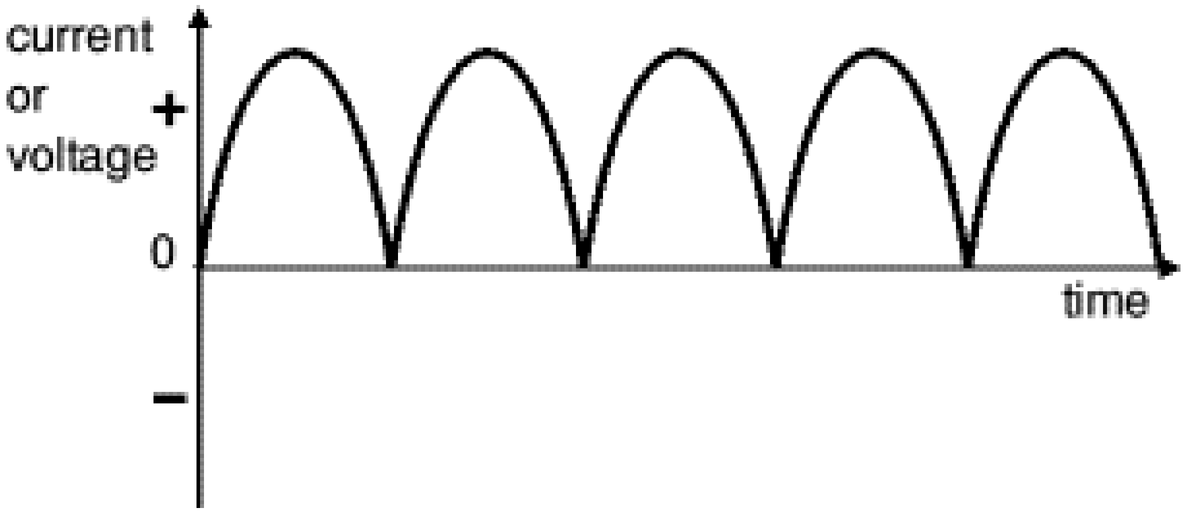

Fig 14 The output of the rectifier circuit.

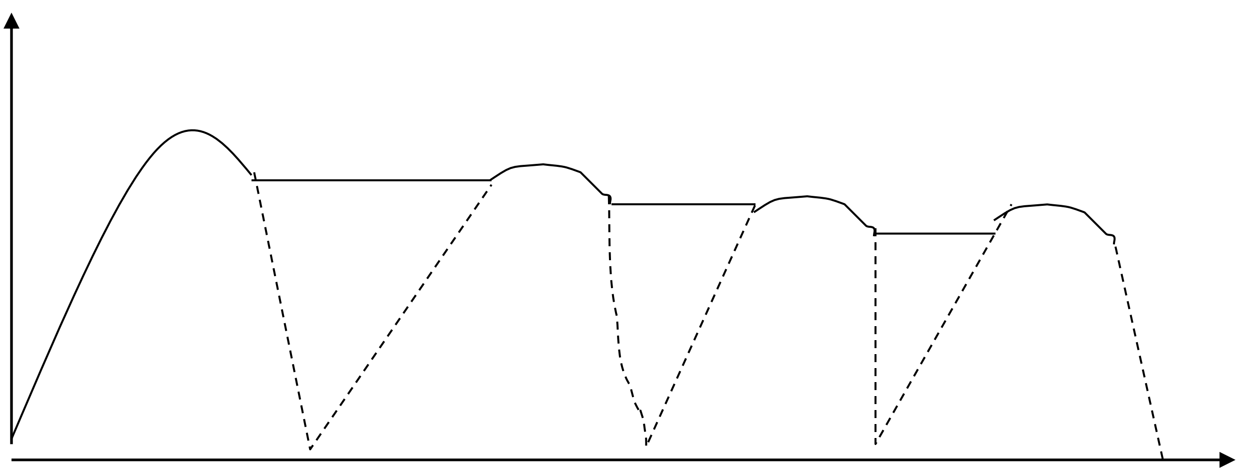

Fig 15 The filtered output of the smoothening capacitor

DESIGN CALCULATION

The ripple voltage can be approximated by the triangular wave form depicted below; which has a peak to peak of Vr (p-p) and a period Tr.

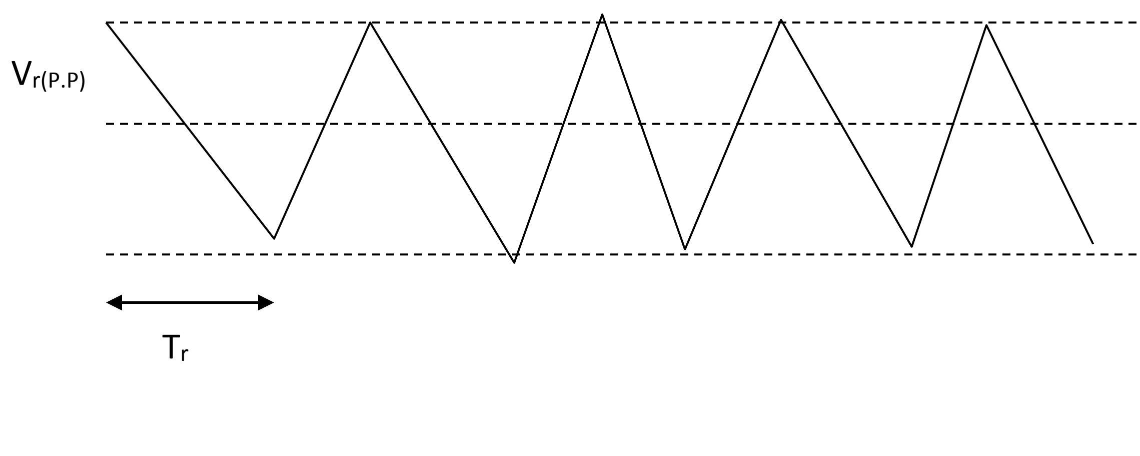

Fig 16 output signal wave form.

Considering the charge lost during the discharge of the shunt capacitor as dq in a time T and is given as:

$d_q = I_{dc} \times T_r$---------------------(1)

Thus, $V_{r\,(p\text{-}p)} = \frac{\mathrm{dq}}{C} = \frac{Idc \times Tr}{C}$ ------------------------(2)

But $I_{dc} = \frac{\mathrm{Vdc}}{Rl}$

Therefore, $V_{r\,(p\text{-}p)} = \frac{dq}{C} = \frac{\frac{Vdc}{Rl}\times Tr}{C}$

Finally, $Vr(p\text{-}p) = \frac{Vdc\times Tr}{RlC}$

But the ripple delay (Period) $T_r = \frac{1}{Fr}$

Therefore; $V_{r\,(p\text{-}p)} = \frac{Vdc}{Rl\,C\;\;Fr}$ ------------------3

Where R_L is the worst case load resistance, ie the maximum circuit resistance = 100Ω

$V_{rms} = \frac{Vr(p-p)}{2\sqrt{3}} = \frac{\mathrm{Vdc}}{2\;\sqrt{3}\;\;\mathrm{Fr\,RL\;\;C}}$ --------------------------4

From equation 4 above; taking the ration of V_{rms} to V_{dc} we get a constant known as ripple factor r_f

Given that $\mathrm{rf} = \frac{\mathrm{Vrms}}{\mathrm{Vdc}} = \frac{1}{2\;\sqrt{3}\;\;\mathrm{Fr\,RL\;\;C}} - - - - - - - - - - 5$

But ripple frequency F_r=100Hz, because it's a full wave rectifier bridge

$$rf = \frac{15}{25.46} = 0.6$$

For the worst case resistance of the circuit, Rl = 100 and assuming a maximum ref 0.6%

Recalling that V_{rms} = 15v, V_{max} = 25.46V

Also noting that $V_{max} = I_{dc}R_L$, therefore $R_L = V_{max} / I_{dc}$.

Hence; $\mathrm{rf} = \frac{\mathrm{Vrms}}{\mathrm{Vdc}} = \frac{1}{2\;\sqrt{3}\;\;\mathrm{Fr\,RL\;\;C}} - - - - - - - - - - 6$

Substitute $R_L = V_{max} / I_{dc}$ in equation 6

$$\mathrm{rf} = \frac{\mathrm{Vrms}}{\mathrm{Vdc}} = \frac{1}{2\ \sqrt{3}\ \mathrm{Fr}\left(\frac{\mathrm{Vmax}}{\mathrm{Idc}}\right)\ \mathrm{C}} ----------- 7$$

from euation 7 it becomes

$$rf = \frac{1}{2\ \sqrt{3}\ \mathrm{Fr}\left(\frac{\mathrm{Vmax}}{\mathrm{Idc}}\right)\ \mathrm{C}} ----------- 8$$

Rearranging the above equation; it becomes;

$$rf = \frac{\mathrm{Idc}}{2\ \sqrt{3}\ \mathrm{Fr}\ \ \mathrm{Vmaz}\ \ \mathrm{C}} ----------- 8$$

$$C = \frac{\mathrm{Idc}}{2\ \sqrt{3}\ \mathrm{Fr}\ \ \mathrm{Vmaz}\, rf} ----------- 9$$

Given parameters are

C=? unknown

V_{maz}=25.46v

F_r=100Hz

r_f=0.6%=0.006

finding I_{dc}

$$Idc = \frac{Vdc}{RL} = \frac{0.636\mathrm{Vmax}}{\mathrm{RL}} ----------- 9$$

But V_{maz}=25.46v

$$Idc = \frac{Vdc}{RL} = \frac{0.636\mathrm{Vmax}}{\mathrm{RL}} = \frac{0.636 \times 25.46}{100} = \frac{16.2}{100} = 0.162A$$

Therefore finding the capacitor C;

$$C = \frac{\text{Idc}}{2\ \sqrt{3}\ \text{Fr}\ \ \text{Vmaz}\, rf}$$

$$C = \frac{0.162}{2\ \sqrt{3}\ \times 100 \times 25.46 \times\ 0.006} = \frac{0.162}{2 \times 1.732 \times 100 \times 25.46 \times 0.006}$$

$$= \frac{0.162}{52.916064} = 0.0030615F$$

C=0.003061f=3061×10^{-6}F

Finally C=3061μF

The commercially available 330μf takes care of this calculated value. Therefore we used 3300uf, 25v capacitor in designing the power supply filter.

4.2.4 THE RELAYS SWITCHES

Relays switches, popularly known as relays are used for switching operations. The relays have contact point which form the normally open (NO) and the normally closed (NC) switches. It has an energizing coil through which the switching contacts can be pulled together or drawn apart to accomplish the NO and NC effects. When a current passes through the coil of the relay, the metal core becomes magnetized and attracts a strip of metal which closes the contacts that form the normally open switch. At this point the normally closed terminal opens.

Removing the energizing voltage demagnetize the metal core which then releases the metal strip to open the NO terminal and close the NC terminal again. Thus, the relay contacts can be opened or closed by simply applying or removing the energizing voltage as required.

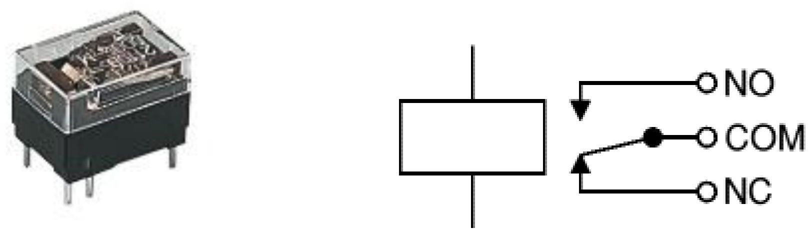

Fig 17 Relay

The relay's switch connections are usually labeled COM, NC and NO:

- **COM** = Common, always connect to this; it is the moving part of the switch.
- **NC** = Normally Closed, COM is connected to this when the relay coil is **off**.
- **NO** = Normally Open, COM is connected to this when the relay coil is **on**.
- Connect to COM and NO if you want the switched circuit to be **on when the relay coil is on**.
- Connect to COM and NC if you want the switched circuit to be **on when the relay coil is off**.

A relay always had some rated values of voltage and current. The rated voltage specifies the amount of voltage needed to energize the coil and ensure that the contact is made at the NO terminals.

Standard relays commonly exist with rated voltages of 5v, 12v and 24v. The rated current in the other hand specifies the maximum load current allowed passing through the contacts. It is a function of the cross-sectional area of the contacts. Relay of rated currents; 5A, 10A, 20A, 30A or higher are commercially available. In the design of my project the rating use in my design is 12V 10A relay switches.

After much design analysis, the complete circuit diagram used in achieving this project is show below with detailed explanation below.

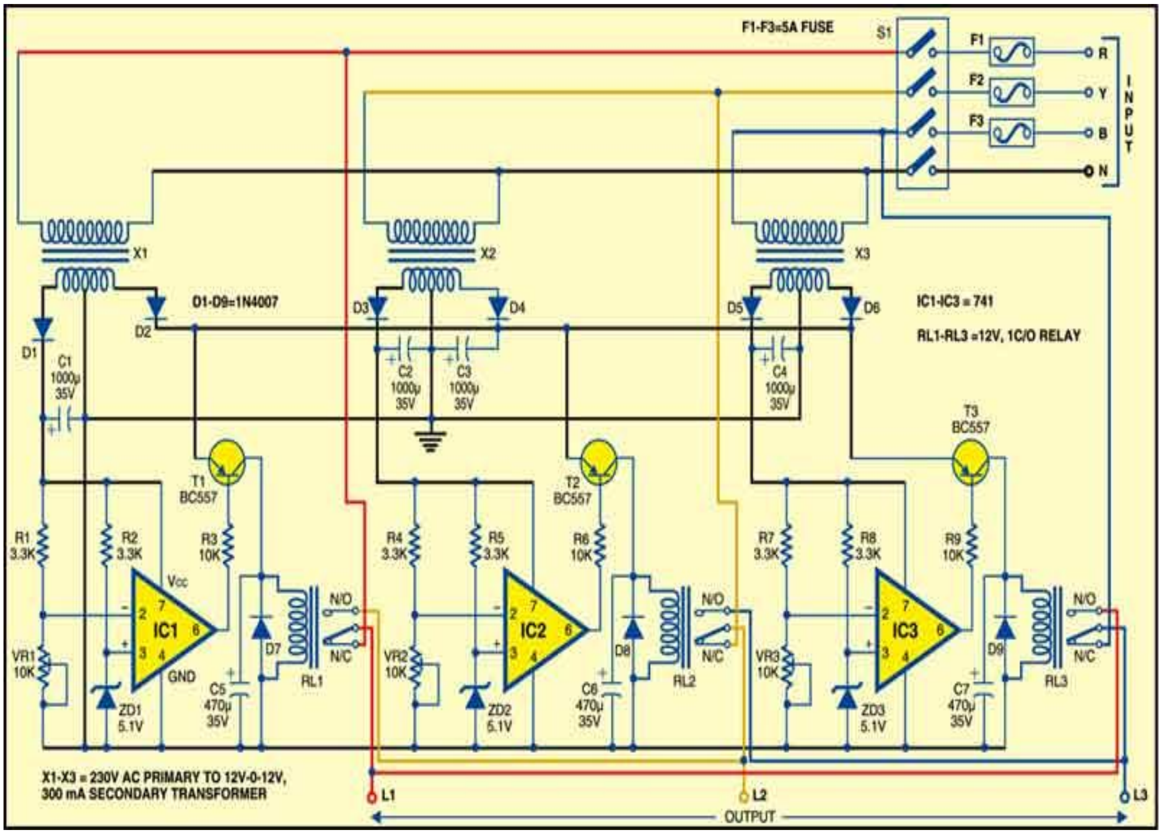

Fig 18 Circuit diagram on automatic phase selector

Some important components of the automatic three phase selector are included below;

1. Transformer (step down transformer 12V)

2. Diodes –IN4007

3. Zener diode -5.1V

4. Capacitor-1000microF, 35V

-470microF, 12V

5. Operational amplifier (LM 741)

6. Resistors- 3.3k, 10k

7. Potentiometer (variable resistor)-10k

8. Relay switches 12V, 400Ω

4.3 DESIGN OF THE CIRCUIT

The circuit is built around with a transformer, comparator, transistor and relay. Three identical sets of this circuit, one each for three phases, used. Here we used a step down transformer and we used LM 741 working as comparator is used here is surrounded by all other components. Transistor BC557 acting as a switch. Relay is the electromagnetic type. The processes under here are divided in to five namely;

- Step down the main supply
- Rectification
- Filteration
- Comparing
- Switching

Main supply R, Y, B is stepped down to desired voltage and current. Each transformer is individually connected to the phases R,Y,B respectively. In this case, only one phase work at a time. The diodes (IN4007) are used to rectify the

AC to DC. The capacitor for removing the noises/ripples in the DC. The resistors and the potentiometer of the circuit give the specified voltage input to the comparator. Based on the comparator output, the transistor (BC557) goes to on and off position. Thus we can say that transistor work as a switch.

The components were mounted on the bread and were wired up. A 12V dc supply was generated. The main circuit consist consist comparator, transformer, transistor and relay. Three identical set of this circuit connected on the breadboard. Then the output is verified by connecting a load (bulb) at the output and got the desired output.

4.4 WORK OF LM 741 COMPARATOR

A comparator circuit compares two voltage signals and determines which one is greater. The result of this comparison is indicated by the output voltage: if the op-amp output is saturated in the positive direction,the non inverting input(+) is greater, or more positive voltage than the inverting input(-),all voltage measured with respect to ground. If the op-amp voltage is near the negative supply voltage(in case,0 volts, or ground potential), it means the inverting input(-) has a greater voltage applied to it than the non inverting input(+).

4.5 COMPARATOR USING OPERATIONAL AMPLIFIER

Often two voltage signals are to be compared and to be distinguish which is stronger. Thus the op-amp comparator is a circuit with two inputs and one output. The two input can be compared with each other i.e. one of them can be considered a reference voltage, $V_{ref.}$

A fixed reference voltage V_{ref} is applied to the inverting (-) input terminal and and sinusoidal signal u_{in} is applied to the non inverting (+) input terminal. When V_{in} exceed V_{ref} the output voltage goes to positive saturation because the voltage at the inverting (-) input is smaller than at the non inverting (+) input. On the other hand, when V_{in} is less than V_{ref} the output voltage goes to negative saturation. Thus output voltage U_{out} changes from one saturation level to another whenever $V_{in} = V_{ref}$. in short the comparator is a type of an analog to digital converter(ADC). At any given time the output the output voltage waveform shows whether V_{in} is greater or less than V_{ref}. The comparator is sometimes referred to as a volt-level detector because for a desired value of V_{ref}, the voltage level of the input voltage V_{in} can be detected. Diodes D_1 and D_2 are provided in the circuit to protect the op-amp against damage due to excessive input voltage. Because of these diodes, the differential input voltage V_d is clamped to either + 0.7V or -0.7V, hence the diodes are called clamp diodes. These are some op-amps with built in input protection. Such op-amps need not to be provided with protection diodes. The resistance R_1 in series with V_{in} is used to limit the current through protection diodes D_1 and D_2 while resistance R is connected between the inverting- input terminal and V_{ref} to reduce the offset problem.

4.6. PRINCIPLE OF OPERATION/CIRCUIT WORKING OF THE AUTOMATIC THREE PHASE SELECTOR

The circuit is built around with a transformer, comparator, transistor and relay. Three identical set of circuit, one each for the three phases are used. Let us now consider the working of the circuit connecting red phase. The main power supply phase R is stepped down by transformer X_1 to deliver 12V, 300mA, which is rectified by diode D1 and filtered by capacitor C1 to produce the operating voltage for the operational amplifier (IC1). The voltage at inverting pin 2 of op-amp IC1 is taken from the voltage divider circuit of resistor R1 and preset resistor VR1 is used to set the reference voltage according to the requirement. The reference voltage at non-inverting pin3 is fixed to 5.1V through zener diode ZD1. Till the supply voltage available in phase R is in the range of 200V- 230V, the voltage at inverting pin 2 of IC1 remain high, i.e. more than reference voltage of 5.1V, and its output pin 6 also remain high. As a result, transistor T1 does not conduct, relay RL1 remains de-energized and phase R supplies power to load L1 via normally closed (N/C) contact of relay RL1. As soon as phase R voltage goes below 200V. the voltage at inverting pin 2 of IC1 goes below reference voltage of 5.1V, and its output goes low. As a result, transistors T1 conducts and relay RL1 energizes and load L1 is disconnected from phase R and connected to phase Y through relay RL2. Similarly, the automatic phase changing of the remaining two phases, via phase Y and phase B can be explained. Switch S1 is main power on/off switch.

4.7 TABLE FOR PHASE SELECTION

INPUT-R	INPUT –Y	INPUT-B		OUTPUT
0	0	0		NO SUPPLY
1	0	0		PHASE –R
0	1	0		PHASE –Y
0	0	1		PHASE –B
0	1	1		PHASE-B
1	0	1		PHASE –B
1	1	0		PHASE –Y
1	1	1		PHASE –B

Fig 19 Table for phase selection

CHAPTER FIVE

SYSTEM TESTING, RECOMMENDATION AND CONCLUSION

5.1 SYSTEM TESTING

System testing is the last step which comes after thorough analysis of the various section explained in chapter four. At this step, the component values specified in the analysis of each were used to realize the section in the breadboard. A system testing involves testing the entire component on the veroboard. The prototype was then functionally tested using standard electronic testing equipment like multimeters, probes, voltmeter etc.

5.1.1. TESTING PROCEDURES AND RESULTS

Here the system is tested with three phase supply system. When the three phase terminal is connected to the pin input terminals of the system, the indicator light emitting diode (LED) comes ON indicating power supply to the system. Just immediately after the powering of the system, one of the LED indicating any of the phases comes ON indicating that one of the lines has being selected and gives an output. It's also applies to the other phases.

PRECAUTION TAKEN DURING SOLDERING AND TESTING

A. For soldering

1. It was ensured that IC socket were used for the IC instead of soldering the chip directly. This enables easy replacement of chip and avoids heating of chip during soldering.

2. It was ensured that the soldering iron was inplugged when not in use

3. It was ensured that all cables and materials that do not require soldering were kept out of reach from the soldering iron.

B. For testing

1. it was ensured that the cables were properly plugged to avoid loose contacts, which may result to arching

2.it was ensured that I was properly insulated to avoid electric shock in the event of current leakage during testing

3. it was ensured that proper ear thing of the hands was done before touching any of the ICs to avoid the damage of the chips due to electrostatic discharge.

5.2 PROBLEMS ENCOUNTERED

1. High transportation expenses: transporting myself to IMT where my supervisor lectures was not easy. Out of the financial support from parents and relations enabled the success of this project.

2. Time factor problem: congested academics activities posed a time factor problem. However, the project was embarked on immediately it was approved and registered

3. Interruption of power supply: soldering of components also suffered a setback because of intermittent power supply by PHCN.

4. Lost of components: during soldering some components were lost to the inexperienced soldering done by me. However replacement was always done in the event of loss.

5.3 RESULT

The implemented circuit is a close reflection of the objective of this work. It simulates an automatic switch with an intrinsic ability of searching for a suitable live wire to hook on to whenever any of the previously supply phase among the three goes dead. The additional feature supported by the voltage programmable current sink internally incorporated into the circuit to skip some very low voltage as it seeks a suitable phase.

To sum up, the result was in accordance to the expectation when the circuit was tested. The design calculations made assured that the internal components of the circuit can work round the clock as it is meant to, without any one getting over heated and burning out. Therefore the longevity of the device as well as the reliability is assured to the user.

5.4 CONCLUSION

This project has illustrated how to design and construct an automatic phase selector. There may be many other ways of achieving a very straight forward way of obtaining the desired result using classical design techniques. The beauty of the work lies in the fact that it can be used round the clock and it can neglect a phase with very low voltage.

The construction of this automatic three phase selector was interesting, stimulating and challenging but only in its efficient performance can any real level of success be measured.

The functionality values of this project make it desirable to be developed especially in all residential and small commercial buildings using three phase. This is to put an end to manual phase voltage monitoring, measurement, selction and switching activities. This project saves resources like time, energy and even lives while ensuring automatic and efficient domestic power load sharing from the consumer end. This project will be economically justifiable if this is to be produced in commercial quantity, although there may be slight variation because the design was carried out based on technical and economical consideration. It is believed that the design will operate at minimal cost and at high efficiency. To ensure conformity with engineering designs, engineering design standards and rules were strictly adhered during the design and construction.

This design does not have any major restriction in the aspect of who to use it and who not to use it nor where to use it and where not to use it. Its applications range from domestics homes, light industries and heavy industries.

5.5 RECOMMENDATIONS

Since there is need for load balancing in a three phase distribution line, a universal usage of this type of phase selector may imply over loading a particular phase which phase voltage is up to the normal required value. Since similar devices will switch on simultaneously to one phase, it should only be advisable to use the device in an exclusive case of power consumption. Moreover every health center all over nations should use this project since it will help to save life at crucial points when power outrage becomes a threat to life.

REFERENCES

Boylestad, R., & Mashelsky, l. (1996). *Electronics Devices and Circuit Theory*. New Jersey, U.S.A: Prentice Hall Inc.

Brumsickle, W. E., Divan, D. M., Luckjiff, G. A., Freeborg, J. W., & Hayes, R. L. (2003). Operational Experience with a Nationwide Power Quality and Reliability Monitoring System*, IEEE-IAS Annual Meeting Conf*. Record, Vol 2, pp. 1063 – 1067.

Conaster, B., Nastasi, D., & Phipps, K. (2002). Following the Trail of Destruction, *Power Quality Magazine,* pp 62-66

Conway, G. A., & Jones, K. I. (2002). Harmonic currents produced by variable speed drives with uncontrolled rectifier inputs*, IEE Colloquium on Three Phase LV Industrial Supplies: Harmonic Pollution and Recent Developments in Remedies,* Page(s): 4/1 -4/5

Curtis, A. C. (2000). *A Handbook on Electronics Design*. U.S.A: Mc-Graw Hill.

Divan, D., Luckjiff, G. A., Brumsickle, W. E., Freeborg, J., & Bhadkamkar, A. (2004). A grid information resource for nationwide real-time power monitoring. *IEEE Transactions on Industry Applications,* Volume: 40, Issue: 2,Pages: 699

Fujita, H., & Akagi, H. (2004). Control and performance of a pulse-density modulated series-resonant inverter for corona discharge processes, *Industry Applications, IEEE Transactions on* , Volume: 35 Issue: 3, Page(s): 621 –627

Greenfield, J. D. (2006). *Practical Digital Design Using Integrated Circuits*. New York: John Willey and Sons Incorporation.

Guasch, L., Corcoles, F., & Pedra, J. (2000). Effects of unsymmetrical voltage sag types E, F and G on induction motors, *Proceedings of the Conference on Harmonics and Quality of Power,* Volume: 3, Pages:796 - 803 vol.3

Haronitz, P. (2004). *The Art of Electronics*. London: Cambridge and Hill University Press.

http://*www.itic.org/technical/iticurv.pdf*, Revised 2000.

Jacobowitz, H. (2000). *Electronics Made Simple*. Great Britain: N.H. Allen and Co. Ltd.

Leon – Garcia, B. (2000). *Fundamental Concepts and Key Architectures of Electronic Circuit Design.* Boston, USA: Mc-Graw Hill.

McGranaghan, M., Gunther, E., & Laughner, T. (2002). Correlating PQ Disturbances with Lightning Strikes, *Power Quality Magazine*, pp8-13, 67

Nagrath, I. J., & Kothari, I. D. P. (2000). *Power System Engineering*. New Delhi: Tata Mc-Graw Hill Publishing Company Limited.

Ransome-Wallis, P. (1959). *Electric motive power: Illustrated Encyclopedia of World Railway Locomotives*. London: Hutchinson. p. 173.

Terrell, C., & Wilford, S. (1987). *American Electricans' Handbook,* (11th Edition). New York: Mc-Graw Hill.

Theraja, B. L., & Theraja, A. K. (2002). *Electrical Technology*. New Delhi: Publication of Ram Naogar.

Thereja, A. K., & Thereja, B. L. (2000). *A Textbook of Electrical Technology*. New Delhi: S Chand and Company LTD.