DESIGN AND CONSTRUCTION OF TWO PHASE AUTOMATIC CUT-OUT FUSING SYSTEM WITH ENGINE SHUT-DOWN SWITCH

BY

ESSIEN ANSWER IBORO

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DECLARATION

I ESSIEN ANSWER IBORO, hereby declare that this project work titled "AUTOMATIC CUTOUT FUSING SYSTEM WITH ENGINE SHUTDOWN SWITCH" was carried out by me under the supervision of Mr Henry Ohize.

1-11-2010

ESSIEN ANSWER IBORO | SIGN/DATE

2005/23715EE

CERTIFICATION

This is to certify that this project was carried out by ESSIEN ANSEWER IBORO under the supervision of Mr Henry Ohize and has been approved for the award of Bachelor of Technology Degree in Electrical and Computer Engineering (B.ENG), Federal University of Technology, Minna.

ESSIEN ANSWER IBORO	1/11/2010
(Name of Student)	(Sign and Date)
OHIZE HENRY	1-11-2010
(Name of Supervisor)	(Sign and Date)
ENGR A. G. RAJI	(Jan. 11 2011)
(Name of H.O.D)	(Sign and Date)
Engr Dr. G. I. Ighalo	1/12/10
(External Supervisor)	(Sign and Date)

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ABSTRACT

The circuit is designed to select one phase of power between two phases when there is power outage in one phase. It is made up of two AC contact relays with holding contact current of 40A, (9.6KW). It has three modes of operation, the normal operating mode where both phases have normal voltage, (220-240) but the main output selected from the default relay based on the circuit design, the shift operating mode, where a low voltage in the default relay, (phase I) causes the circuit to change from phase I (default) to phase two (slave), and the emergency operating 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 installation is to be made. The system also incorporate an engine switch which automatically shutdown the generator set when power is restored.

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CHAPTER ONE

1.0 INTRODUCTION

Generally, electrical cut-out fusing system and engine shutdown circuit allows switching from one phase to another phase of the same source (utility). It is employed in some electrical power distribution system and does shutdown an emergency power source (Generator engine). Most often, cut-out fusing is done by removing the fuse/cut-out from one phase to another. The cutout fusing system may be manual, automatic or a combination of manual and automatic.

During power outage in Nigeria, most homes and offices suffers partial outage i.e. one of the phases usually goes off from the transformer (main power supply). The cutout fusing system allows changing of the cutout fuses manually or even starting the generator engine in the case of complete power outage.

1.1 MOTIVATION

Regular power supply is the prime mover of social and technological development in any country. There is hardly any enterprise and indeed any aspect of human development that does not require energy in one form or the other; electrical power and fuels etc. it is very sad that we live in a country that is richly endowed with various energy sources such as crude oil, natural gas, coal, hydro-power, solar energy, fissionable materials for nuclear energy and yet there is no stable power supply. It is a major impediment to the industrial and technological growth in the nation. The Power Holding Company of Nigeria (P.H.C.N), a government parastatal that has the sole responsibility for managing power generating plant as well as distribution of power nationwide has failed to live up to its expectation as its performance has caused uncountable woes on the people of the country. Nigerians have continued to bemoan their fates in the hands of P.H.C.N regarding the power supply experience in the country.

This 'epileptic' power situation has caused a lot of discomfort in some homes. Important programmes such as television programmes, radio programmes, public functions to mention a few are often interrupted. Businesses are also not left out of this menace as it causes a great deal of cost, loss and delay in keeping to agreement between business men and their client as well as distrust and suspicions.

Therefore, in other for people to enjoy the comfort of their homes and for companies to remain in business, they are left with the painful option of changing of cut-out fuses or the choice of generating their own power, thereby spending so much so on fuels since generators don't run on water and there is also the risk of going closer to electric cut-out fuse board. The fuel price in Nigeria is always on the high side and in this case there is the need to be sure that the generator set is well serviced and its tank is full of fuel so that the home brightens before power returns.

Ironically, the unstable or almost near zero power supply is not reflecting in the charging bill of P.H.C.N. The charging system seems to reflect more on what a residence or company is suppose to consume in a month without power outage than what is actually been supplied, sometimes the assessment seems to be based on the size of a building and not on what is actually happening inside.

Now, if Nigerians are left with the options of purchasing generating set and fuelling this generator, it is therefore pertinent on them to make the maximum possible benefit out of the difficult situation. This means that the generator must not be allowed to run on extra minute whenever the public mains power is restored. This will ensure that the fuel is not allowed to waste whenever there is power from P.H.C.N. Hence, fuel is saved and when the mains returns, the fusing system will automatically shut-down the generator set (Stand-by power source). This will in addition also prolong the generators life span. This is what brings about the ideal of automatic cu-tout fusing system and engine shut-down switch.

The cut-out fusing system and engine shut-down switch is designed in such a way that the generator will only work when there is power outage and automatically stop running immediately the utility power is restored.

1.2 AIM AND OBJECTIVES

- To minimize or eliminate fuel wastage
- To prolong Generator's life span
- To minimize cut-out fuse changing time
- To eliminate the risk of going near the cut-out fusing board

1.3 SCOPE

This project is limited on the design of two phase cut-out fuse. The cut-out fuse changes power source automatically when power is interrupted or even starts the generator engine in the case of complete power outage.

1.4 METHODOLOGY

This 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 of available devices and other necessary components. Each unit consists of different electronic components which perform different operations necessary for the overall of the system.

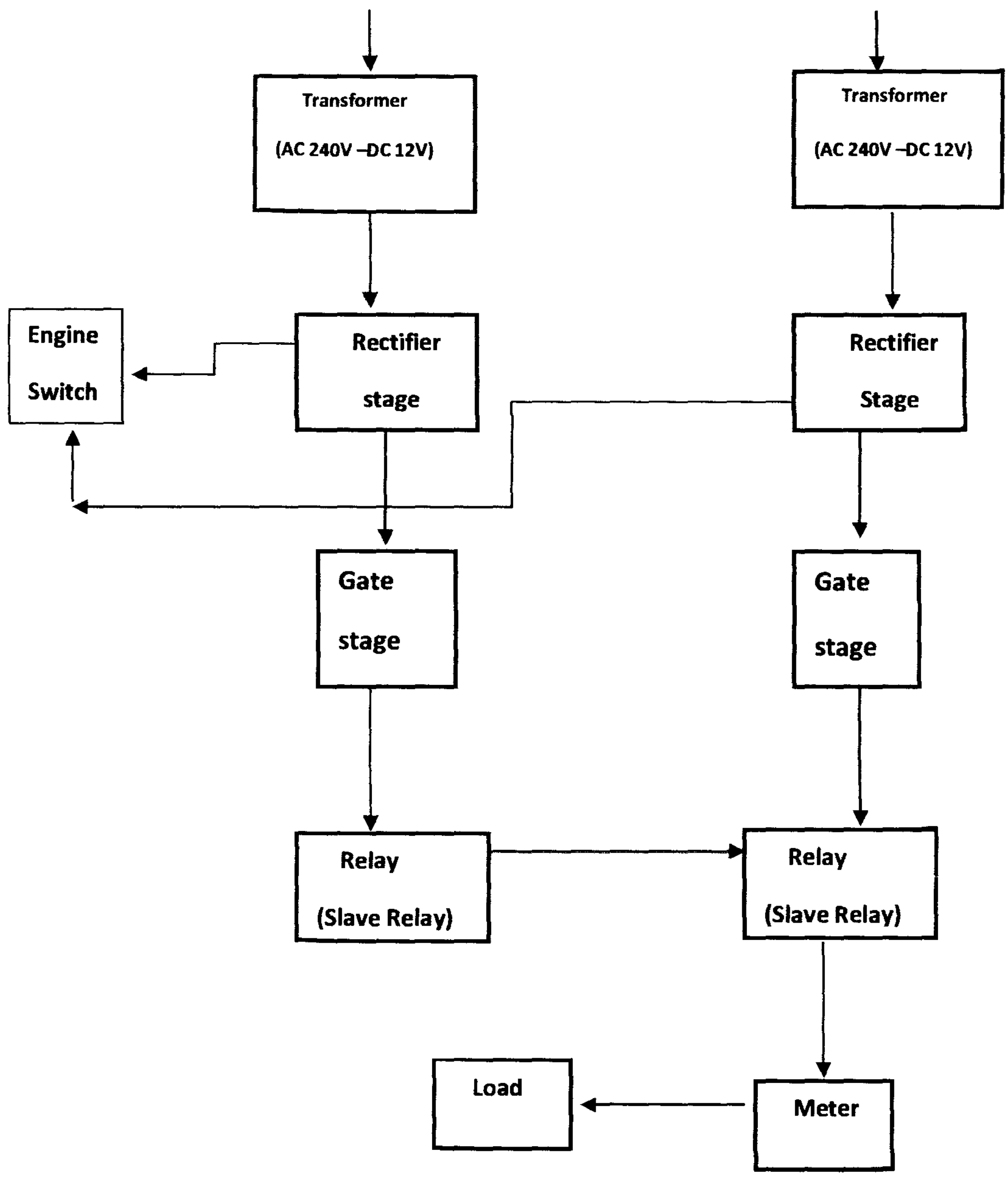


Fig 1.1 Block Diagram of two phase Automatic Cut-out fuse Circuit System with Engine Shutdown Switch.

Figure 1.1 shows the fundamental block diagram of the Automatic Cut-out Fuse Circuit System with Engine Shut-down Switch which clearly states all the stages involve in the design circuit.

CHAPTER TWO

2.0 LITERATURE REVIEW

Due to failure of power supply, or an alternative for safe phase changing power supply, most buildings have a manual cut-out fuse.

The system of manual phase change over board using cut-out fuse is perfect but we need to have a better perfect way phase changing, this change over from one line of utility to operate between two sources of PHCN, the cut-out fuse is an additional protector of any high voltage between the sources.

In view of the above manual phase changer over using cut-out fuse involves a lot of risk and use of energy in going step away to change over cutout fuse and vise versa, when power supply is being restored and also in hospitals in case of operation, sometimes one phase is not restored usually from the transformer.

2.1 HISTORICAL BACKGROUND

For more than a century now mankind has so much depend on electricity to the extent that he can hardly survive without it.

Mr. Gordon Chapp, a former General Manager of the Tenness Valley Authority in the United States of America (USA) once said that "if you would destroy a region, destroy its power supply. If you would hold a region to a lower standard of living, place a limit on it supply of electricity".

Since about 1879 when Thomas Edison invented the electric bulb, man has not relented in his endeavour to find other uses for electricity, he has used it as a labour saving device in agriculture, in medicine and in industry, for comfort and preservation and indeed for the satisfaction of widest possible spectrum of human needs in all that versatility of electric power has given him the greatest dominance he now exercises over nature.

From the McGraw Hill Dictionary of Science and Technical Terms, a switch is defined as "A means of moving a circuit from one set of connection to another" This implies that an "automatic cut-out fuse changing switch is a means of moving a circuit from one set of connection to another by means of automatic.

Power cut-out fuses are inclusive in the buildings of electrical wiring and electricity. One of the known contributors to electricity was Benjamin Franklin who proved lighting is electrical rod in 1752. Another was George Ohm who postulated the ohm's law (V=IR), and another was the development of a bulb in 1879 by Thomas Edison, he also establish the first power plant in 1881.

(B. L Theraja and A. K Theraja, 2005)

The first standard commercial electricity supply was made in 1897 known as the electric code and the first successful hydro power projects was Niagara fall in USA.(Paker, 1992).

In the beginning of the twentieth century, different companies in the USA started manufacturing and development of electric building wiring devices, such as the cutter manufacturer company located in Philadelphia and the National Electric Company (N.E.C), they produced electric element such as circuit breakers, fuse boxes, power changers and lots more. Their technologies were based on modern electronics controls. (Uwaifo, 1994)

However an electric circuit could only be build to perform or improve on electricity power with less interruption and low consumption of fuel with the use of electronics components.

2.2 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.

2.2.1 Passive Component

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

i. **Capacitors: -**

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: -

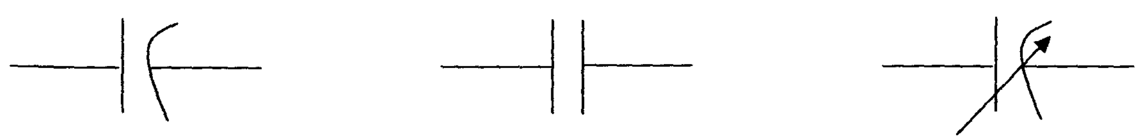
Capacitors are used as follow:-

- 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 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. (http:/www.wikipedia.org/wiki/capacitor)



(a) Polarized Capacitor (b) Non-polarized Capacitor (c) Variable Capacitor

Fig. 2.1 Types of Capacitors (symbols)

ii Resistor: -

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) Fixed Resistor:-

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/ chrone) (http:/www.wikipedia.org/wiki/resistor)

The primary characteristics of a resistor are the resistance, the tolerance, maximum working voltage and the power rating. Other characteristics include 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 its 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.

(b) **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

Fig. 2.2 Types of Resistors (symbols)

ii. 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 to one or more secondary 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. (http:/Wikipedia.org/wiki/transformer)

Type of Transformer

- Audio frequency Transformer
- Radio frequency Transformer
- Power Transformer

Power Transformer:-

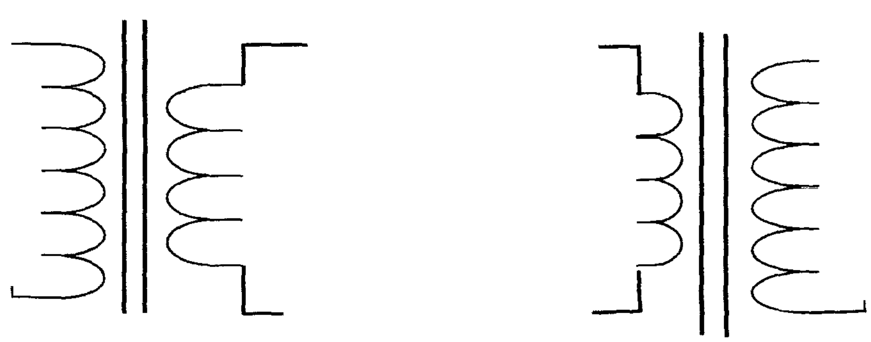
A power Transformer transform at 50-60Hz AC line power to the voltage suitable for rectification to the desire regulated DC.

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

Fig. 2.3 Types of power Transformer

iii. **Diode: -**

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 $I \leq 1A$. The term rectifier is used for power devices, i.e current $I > 1A$. (http:/www.allaboutcircuits.com/vol-3/chpt-3/1.html/)

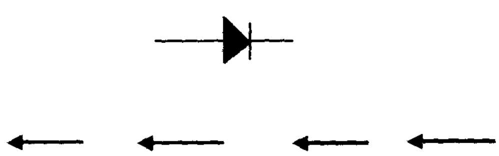


Fig. 2.4 schematic symbol of semi-conductor diode: Arrow indicates the direction of electron current flow.

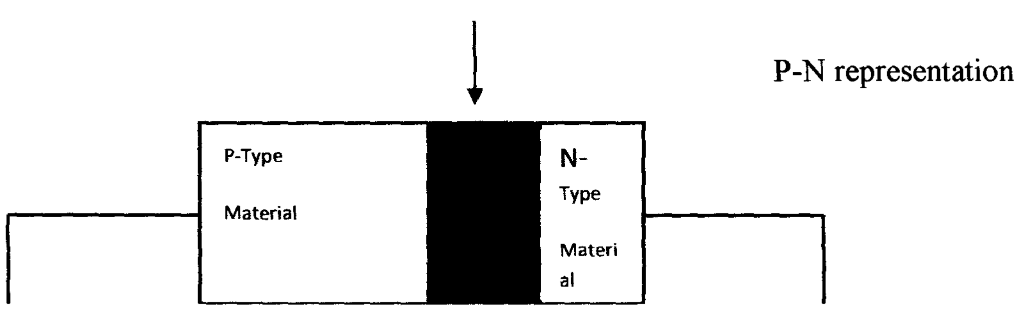
When placed in a simple battery-Lamp circuit, the diode will either allow or prevent current through the lamp depending on the polarity of the applied voltage.

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.

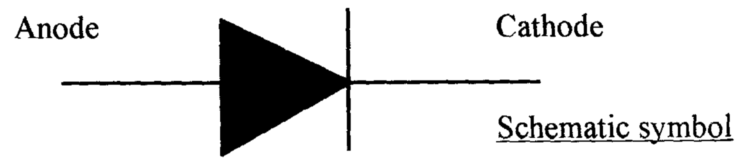
A forward-biased diode conducts current and drops a small voltage across it, leaving most of the battery voltage dropped across the lamp. If the battery polarity is reversed, the diode becomes reversed-biased and drops all of the battery voltage leaving none for the lamp. If we consider the diode to 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-vollts)

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. (fig 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)

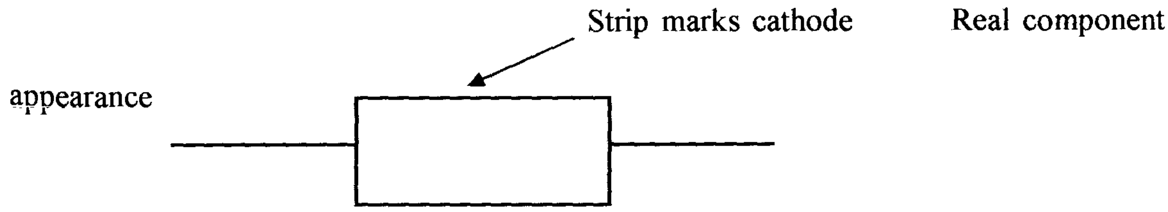


Fig. 2.5; diode representations: PN- Junction model, schematic symbol and physical part.

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. (http:/www.allaboutcircuit.com/vol-3/chpt-3/1.html/)

Types 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.

2.2.2 Active Components

An active electronic components is a circuit component that requires external power to perform its functions. The most common active components are:

i. Transistor

ii. Integrated circuit

i. Transistors

A transistor is a semiconductor device commonly use to amplify or switch electronic signal. A transistor is made up of a solid piece of a semiconductor material, with at least three terminals for connection to an external circuit. A voltage or current applied to one pair of the transistors terminals changes the current flowing through another pair of terminals. Because the controlled (output) power can be much more than the controlling (input) power, the transistor provides amplification of a signal. Some transistors are packaged individually but are found in integrated circuits.

The transistor is the fundamental building block of modern electronic devices, and its presence is very common in modern electronic systems. It has three terminal device used in switching and amplification of signals. There are two principal classes of transistors:

i. Bipolar Junction Transistors (BJTs)

ii. Field-effects Transistors (FETs)

These transistors are made as discrete small signal and power devices. Variations of them are integrated into digital and analog or linear ICs. The small discrete BJTs remain popular in low frequency and linear circuits,while small signal discrete FETs meets the requirement for high-inputs impedance transistor, but discrete metal oxide semiconductor (MOSFET) transistor are preferred for high frequency switching. The BJT transistors can be made in two different configurations. (http:/www.wikipedia.org/wiki/transistor)

a. NPN transistor

b. PNP transistor

2.2.3 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 (SSRs). 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.

(a) Schematic symbol

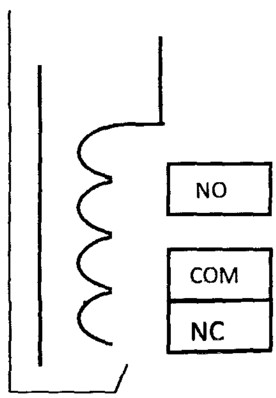


Fig. 2.6 The relay and contact positions.

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

Electromechanical switches for electronics are small mechanisms with electrical contact that permits 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

2.3 PROJECT OUTLINE

The first chapter with the Introduction, how cut-out fuses are carried out manually and then how automatic cut-out fuse can replace the manual one because of the advantage of the former over the latter.

The second chapter presents the literature review and components used in the design of the project.

The fourth chapter deals with the construction, casing and packaging of the project and the fifth chapter summarizes the whole work with the conclusion and recommendation

CHAPTER THREE

3.0 METHODOLOGY, DESIGN AND SPECIFICATION

The method adopted in the design of cut-out fusing system switch depends on the desired holding contact. It breaks contact with one phase of power before it makes contact with another. It can not make back-feeding because it passes through change over panel from an emergency generator power source. During the split seconds of the power transfer or contacts, flow of electricity is interrupted. When testing or when re-transferring to another phase, the switch will operate in make-before-break mode provided both sources are acceptable (two phases). The toggle switch allows you to shift phase in the case of voltage sags or high voltage, which involves transfer from one durable source, and in case of emergency (repairing or installation of some electrical fittings, and fire outbreak). Transfer occurs in this case, for reasons other than a total loss of power which allows you to start generator and make change over.

3.1 COMPONENTS DESIGN SELECTION

3.1.1 POWER SUPPLY SELECTION

The power supply for this project is single 12 volt supply obtained from 240V/12V AC power transformer. The 12 volt is use for the operation of the system to produce the desired result.

3.1.2 Transformer selection

The transformer is selected to deliver at unity power factor.

Power voltage, E_p = 240V

Secondary Voltage, E_s = 12V

Transformer ratio, R_T = E_p/E_s

= 240/12 = 20

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

AC Current, I_{AC} = 300mA

DC Current IDC $= 2\sqrt{2}/\pi \times I_{AC}$

$= 2\sqrt{2}/\pi \times 300 \times 10^{-3}$

= 0.27A

=270mA

3.1.3 Rectification selection

DC Voltage across the rectifier, $V_{DC} = V_{AV}$

12 x $\sqrt{2}$ = 17V

Peak inverse voltage, $P_{IV} = 2 \times V_{DC}$ = 34V

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

The diode in full bridge rectifier circuit must have a PIV rating twice the value of the peak voltage developed at the output; a commercial purpose full wave bridge rectifier was selected for rectification with four leads.

The two extreme leads are the AC input, while the middle two lead serves as positive and negative.

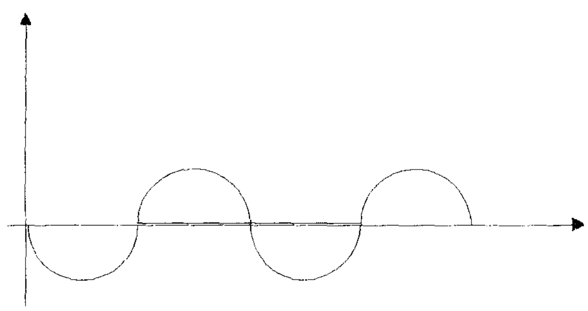


Fig. 3.1 Input wave form AC Supply

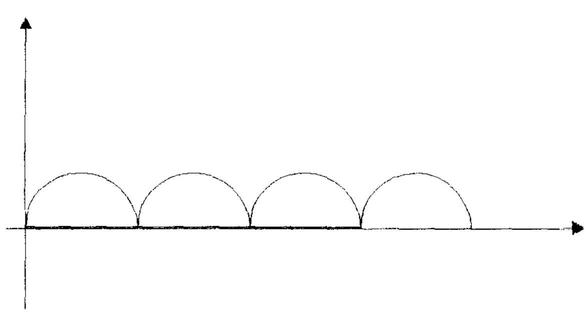


Fig. 3.2 The rectifier Output waveform

3.1.4 Capacitor selection

The smooth of smoothening capacity can be obtained from a supply frequency of 50Hz. The output waveform in fig. 3.2 is the converted AC before capacity. A ripple voltage is removed through filtering or smothered DC voltage by a 25V, 470μF capacitor.

(Rocks and Mazur, 1993).

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

$$\text{But}\, C = {I_{dc}}/{2fV_r} = \frac{270 \times 10^{-3}}{2 \times 50 \times 5} = 540\mu F$$

But practically, there is no 540µF capacitor, rather a closer value which is now 470µF is selected for the circuit.

3.1.5 Capacitor Voltage

V_c = 1.5 x V_{dc}

= 1.5 x 17 = 25.5 to NHN

= 25.5V

Hence, an electrolytic capacity was selected for smoothening capacity, bearing in mind that the higher the value of capacitance, the lesser the ripple.

3.1.6 Gate Selection

A NOT gate discrete circuit was used to control the operation of the actuators (relays) that deliver power to the load. It consists of four bipolar transistors, two acting as a switch while the others act as a relay driver transistor.

The operation of the gates is discrete from the truth table below. It is a gate with 1 input with 1 output. And the output is used to control the state of the relays.

Table 1: Truth Table of NOT Gate

INPUT	OUTPUT
1	0
0	1

According to the above truth table input must go low before output will go high, vice versa.

3.1.7 Relay Selection

i. Relay (Power Supply Relay)

There are two types of AC relays in figure 2.1 (i.e. in Chapter two) with holding contact current of 40A (230/240AC) voltage. They have a 12V DC operating voltage, 170Ω internal resistance, 0.07A as operating current driver transistor.

When an electric current is passed through the coil, the resulting magnetic field attracts the armature and the consequent movement of the movable contact either makes or breaks a connection with a fixed contact. If the set of contacts was closed when the relay was de-energized, then the movement opens the contact and breaks the connection, and vice versa. When the current to the coil is switched off, the armature is returned by a force approximately haft as strong as the magnetic force, to its relaxed position. Usually the force is provided by a spring.

ii. Relay (Engine Switch Relay).

There is also a 12 volts DC relay with holding contact of 10A and internal resistance of 405 Ω, 0.03A as operating current driver transistor. It is driven by the output of both rectifiers. This is to enable it sense power signal from both phases to shutdown the generator, and remain active until both phases are out of power supply (power outage) from mains.

CIRCUIT CONFIGURATION

T1 and T2:	12 Volt Transformers (230 – 240V x 12V)
C1 and C2:	470µF – 25V Capacitors
Q1, Q2, Q3 and Q4:	2N2222 Transistors
D-RL2:	Default Relay (Phase 1 Power Supply)
S-RL1:	Slave Relay (Phase 2 Power Supply)
RL3:	Engine Switch Relay
R1 and R4:	10KΩ Resistors
R2,R3,R5 and R6:	1KΩ Resistors
All 13 Diodes:	Same (i.e. 1A-50Hz: 1N4001)
Sw1:	Emergency Toggle Switch
Sw2:	Shift Toggle Switch

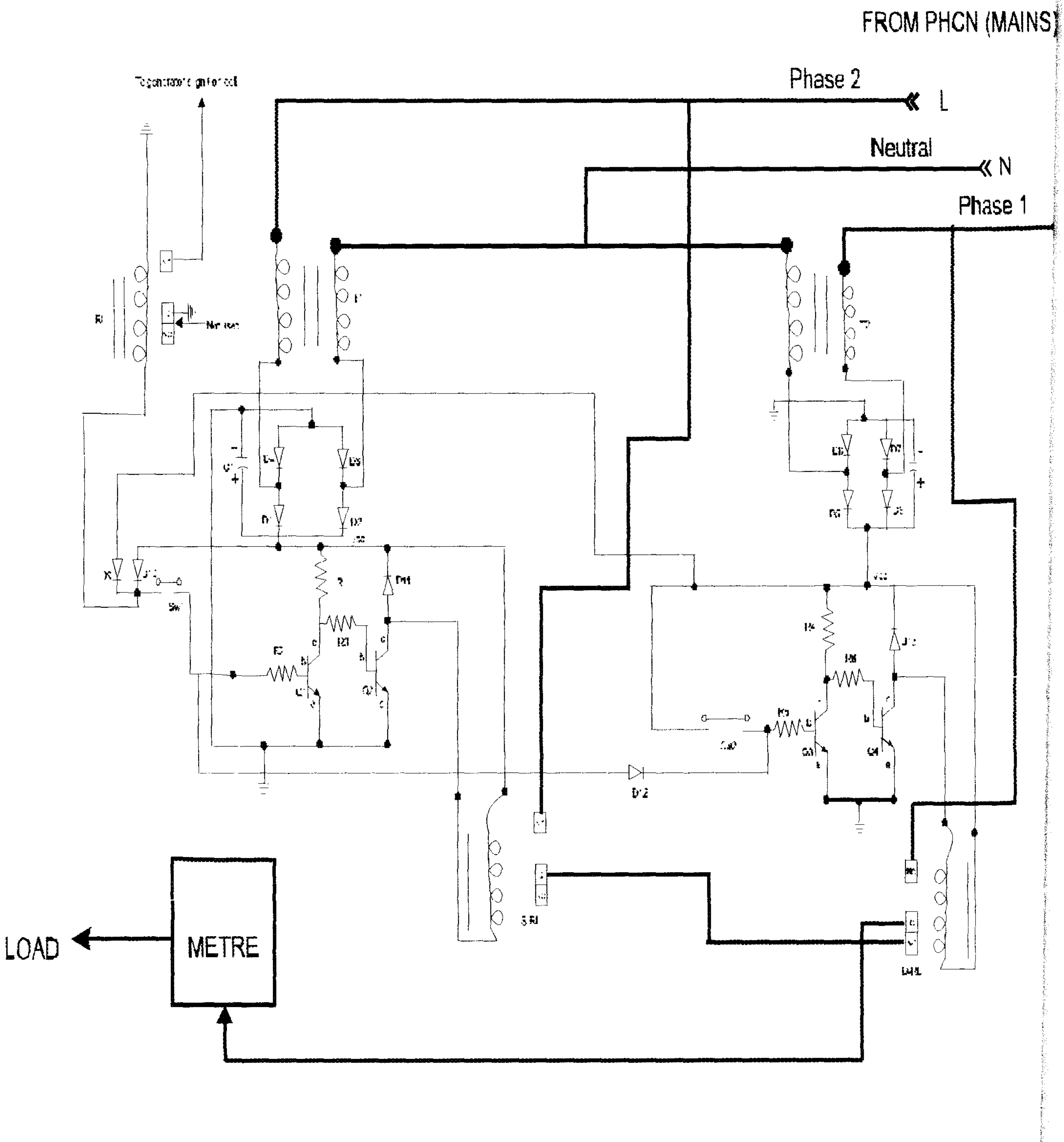


Fig. 3.3: Schematic Diagram of Automatic Cut-out Fusing System with Engine Shutdown Switch

CHAPTER FOUR

4.0 TEST, CONSTRUCTION AND DISCUSSION OF RESULTS

4.1 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 implementing the project involve the use 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***

This digital multimeter basically measures voltage, resistance, continuity, current, frequency, temperature and transistor. The process of implementation of the design on the board requires the measurement of parameters like charges, continuity, current and resistance values of the components.

- ***Power Supply***

The Power Supply is used to supply AC voltage to the various stages of the circuit during the Bread Board test before soldering it on the Vero Board. It is also used to test various stages of designed circuit and then finally soldered on the very Board.

- ***Lead***

A lead is a flexible soldering wire capable of melting under a high temperature condition. It is used to solder connections and components together to the appropriate place on the vero board.

- ***Soldering Iron***

A soldering iron is a low power heating element typically of 60 watts. It provides the needed temperature to melt the soldering lead so that it can hold the connection or component together permanently on the vero board.

- ***Lead Sucker***

It is used to suck out melted lead from the vero board so as to allow on one remove a non-active component or unusual electrical connection.

- ***Wire Cutter/Stripper***

These tools are used to cut wires to the desired size required as well as stripe off the wire edge for the connection in other to expose inner conducted wires for proper and neater soldering.

- ***Bread Board***

It is used temporarily 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 soldered on the vero board.

- ***Vero Board***

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

4.2 DISCUSSION OF RESULTS

The discussion of the results is classified into different modes of operation as mentioned below:

- Normal Operation Mode
- Shift Operation Mode
- Emergency Operation Mode

4.2.1 Normal Operation Mode

In normal operation mode, both phases have normal voltage but the main output is selected from the default relay based on the circuit design. This is possible because the output from the slave relay (Phase II) was fed to the normally open (NO) contact of the default relay (Phase 1) and since the default relay is active, the common (C) contact will move away from its normally closed (NC) contact to the normally open (NO), thereby feeding the main output (load) through the default relay. Table 2 and figure 4.1 below describe the operation of the relay

Table 2: Truth Table Describing Normal Operation Mode.

	Default Relay (Phase I)	Slave Relay (Phase II)
Normally Open (NO)	1	0
Normally Close (NC)	0	0
Main Output	**1**	**0**

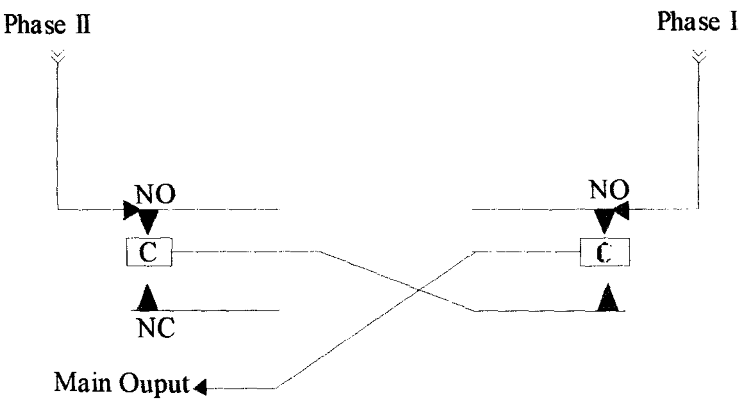


Fig. 4.1 The State of the Relays in Normal Operation

4.2.2 Shift Operation Mode

In the shift operation mode, when there is low voltage (26V to 29V) in the default relay, it changes from Phase I (Default) to Phase II (Slave) automatically. But when the voltage is in the range of 30V – 189V, the toggle switch is used to change the phase. Also, whenever the voltage comes up to 190V to 240V, it changes automatically back to the default. This is possible because the output from the slave relay is fed to the normal closed (NC) contact of the default relay (Phase I) and since the default relay is active but low voltage, the common (C) contact will shift from the normally open (NO) contact of the default relay thereby feeding the main output (Load) through the default relay. Table 3 and Figure 4.2 below describe the state of the operation of the relay.

Table 3: Truth Table Describing Shift Operation Mode.

	Default Relay (Phase I)	Slave Relay (Phase II)
Normally Open (NO)	0	1
Normally Close (NC)	1	0
Main Output	**0**	**1**

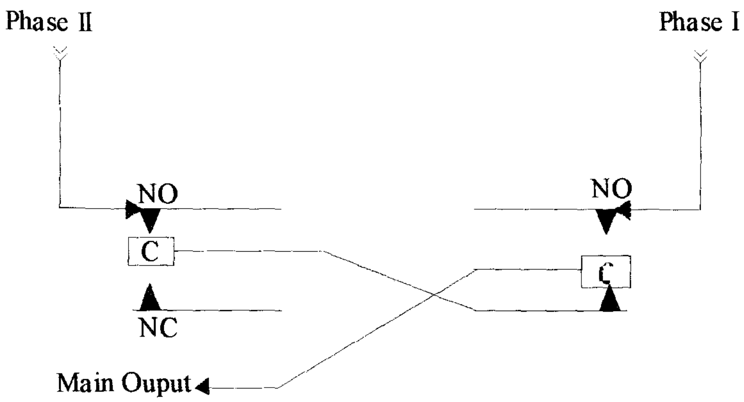


Fig. 4.2 The State of the Relays in Shift Operation

4.2.3 Emergency Operation Mode

In the emergency operation mode, 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 (i.e. the output to the load is low because the outputs of the default relay and the slave relay are low). This is possible because the output from slave relay was fed to the normally close (NC) contact of the default relay (Phase I) and since the default relay is not active, the common (C) contact will move to the normally close (NC) contact thereby feeding the main output (Load). Table 4 and Figure 4.3 below describe the state of the operation of the relays.

Table 4: Truth Table Describing Emergency Operation Mode.

	Default Relay (Phase I)	Slave Relay (Phase II)
Normally Open (NO)	1	1
Normally Close (NC)	0	0
Main Output	**0**	**0**

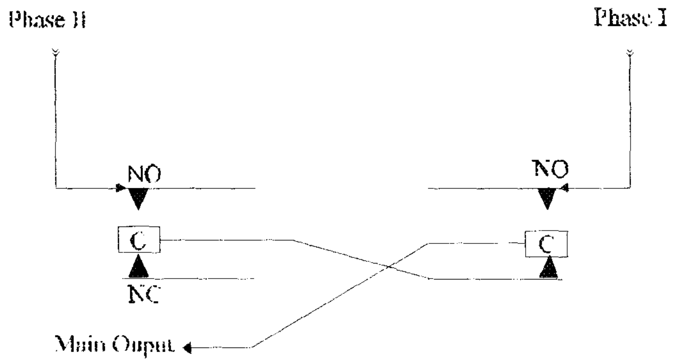


Fig. 4.3 The State of the Relays in Emergency Operation

It was noted that during the emergency and shift modes, the engine switch remains actively high. Therefore, the state of both default and slave relay will not allow generator to start.

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 Connections for emergency and shift operation mode

d. Engine Switch cable connection

e. Power Output to load

a. Circuit Positioning

The constructed circuit (Automatic cut-out fusing system with generator shutdown) was mounted on a wooden board or insulator and screwed to the wall in a ventilated area because the circuit has two transformers that produce heat when in operation. This will prevent it from burning.

b. Phase Connection

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

c. Plug Connection for emergency, shift operation mode

Three jack plugs were connected to their right sockets position before powering the circuit. Two plugs are connected with two toggle switches (emergency and shift operation mode) while the third jack plug is connected to the generator's switch. Putting jack plugs in the right position (sockets) is important to avoid abnormal operation of the circuit.

d. Engine switch cable connection

A single gable is connected to the normally open (NO) contact of the engine switch relay. This was connected to the ignition coil terminal going to the spark plug centre electrode terminal of a petrol engine. It is the wire that is connected to the engine switch that stops the generator.

e. Power output to load

This receives power from the mains to the circuit with an operation current that is less than 40A (9.6kW). the circuit is designed to select one phase to the load when in operation.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

After the design and construction, various tests were carried out and the results obtained demonstrated that the Automatic cut-out fusing system with engine shut-down switch achieved its aim. The system worked according to specification and it was quite satisfactory. This is an automatic system switch which is relatively affordable and reliable. It is easy to operate and a good holding contact of 40A (9.6KW). Finally, it reduces stress associated with manual cut-out changing fuse. Also, the engine switch automatically shuts down the generator when P.H.C.N. restores power.

5.2 RECOMMENDATION

The following are the recommendations for further improvement:

1. The project should be incorporated with auto start circuit for generators
2. A voltage level comparator should be incorporated into the circuit so that the circuit can make an automatic shift from one phase to the other when the voltage drops in the range of 30V – 189V instead of using the toggle switch.

3. The circuit should be incorporated with fire alarm system, and automatic emergency operation mode in case of fire outbreak.

4. Some programmable components can be used so as to reduce the entire size of the circuit.

5. For convenience, automatic change over circuit can be incorporated so as to switch on the generator automatically when there is power outage.

6. High current capacity relays should be used so as to increase the holding contact and the amount of load

7. The circuit could be further modified to accommodate a 3 – phase power line

8. Both shift and emergency modes can be controlled by the use of remote instead of the toggle switch.

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