DESIGN AND CONSTRUCTION OF A SINGLE PHASE AUTOMATIC CHANGE OVER SWITCH

BY

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TO THE DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING AND ENGINEERING TECHNOLOGY.

IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF ENGINEERING OF THE FEDERAL UNIVERSITY OF TECHNOLOGY MINNA, NIGER STATE.

DECEMBER 2000

DECLARATION

I hereby declare that this project work was wholly and solely conducted by me under the supervision of Mallam M.S Ahmed in the Department of Electrical and Computer Engineering. Federal University of Technology Minna.

....

OBEH A. MONDAY 91/1758

....

DATE

CERTIFICATION

This is to certify that the project was designed and constructed by OBEH A. MONDAY.

SIGN
PROJECT SUPERVISOR
DATE:--------------------

SIGN
H.O.D
DATE:------------------

SIGN
EXTERNAL EXAMINER
DATE: 7/1/01

DEDICATION

This project work is dedicated to my lord and personal saviour Jesus Christ.

ABSTRACT

In Nigeria today there had been a problem of constant power failure which is affecting many industries and firm in production and manufacturing of goods and services.

For this reason the design and construction of a device which will minimize this power failure to an extent is carried out.

The Automatic change over switch is a device design to switch from the utility e.g N.E.P.A to Generator when there is power failure from the utility and it will switch back to N.E.P.A when the utility is on.

The process by which this perform its functions is by means of relays which switches on and off Automatically.

This project explains in details the operation of the circuit and other system involved.

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The use of generators now come into focus as an alternative to the power supplied by the utility (National Electric Power Authority, N.E.P.A, in case of Nigerian). Generators can be switched on either manually or by automatic means, to serve as an alternative power Source on the failure of power supply, from the utility.

Switching the generator manually, howevers, has the dis-advantages of being tasking and time consuming, especially if the generator set is located some distance away from the point of usage (which is not uncommon). Hence, the need to design an automatic change-over switch.

From the McGraw Hill Dictionary of Science and technical terms, a change over switch is defined as "A means of moving a circuit from one set of connection to another. [2]

From this definition, it implies that an Automatic change over switch is" A means of moving a circuit from one set of connection to another by automatic means"

The automatic change over switch requires no human effort as compared with the manual change over switch This makes it less tasking (since an operator would not be necessary) and time saving as switching could be achieved within few seconds.

Many automatic change over switching designed previously are quite expensive because they incorporate the use of high voltage contactors and relays to achieve switching.

However, this project was designed and constructed in order to mininize cost by using low voltage D.C relays and still achieving higher efficiency.

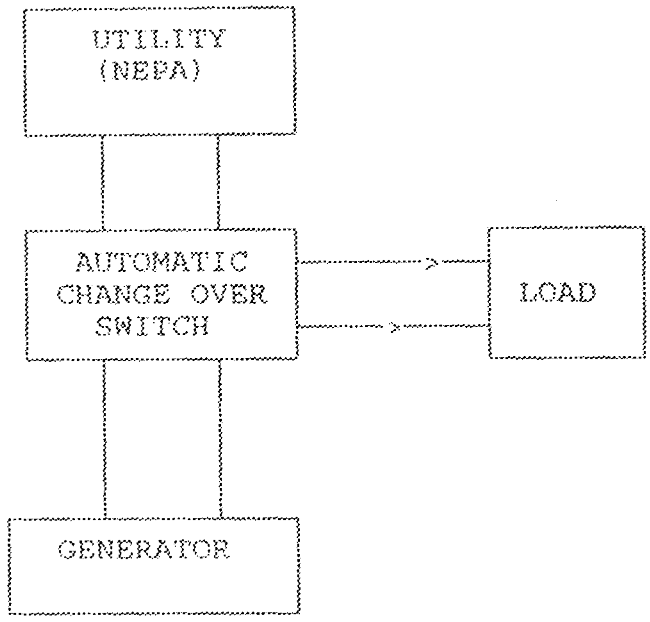


Fig. 1.1 shows the block diagram of how the automatic change-over switch is connected to both the generator, the utility and the load.

1.2 PROJECT OBJECTIVE/MOTIVATOR

The aim of this project is to bring to a hall the failure of power supply at any time as this affect many activities in industries and commercial centre.

This can be done by the connection of this project design and construction of an Automatic change over switch in between the utility and a stand-by Generator. It will be observed that during N.E.P.A failure there will be an Automatic switch on of the generator to supply electricity and when N.E.P.A is on, there will be a switch back to utility; by so doing there will be constant supply of electricity.

This is what gave the impetus to design and construct the automatic change over switch which would solve the problem of manpower and the danger that may likely be encountered during operations in hospital.

Subsequently in this project is planned to use power relay but it is not available. In view of this. I then used a 12VDC relay which involved the use of transformer and rectification process. The issue of transforer and rectification would not have come into play if it were power relay since the power relay can withstand the A.C supply directly.

Based on this project, the maximum power rating capacity was found to be 2.4 KVA. This slows that a generator of power rating ranging from 0.24KVA - 2.4KVA can be used for this project; Since voltage and current rating from data book was found to be 2.4VDC and 10 Amperes contact rating of the relay respectively.

CHAPTER TWO

THEORY OF OPERATION

2.1 SWITCHING APPARATUS FOR POWER CIRCUITS

DEFINITION:-Switching apparatus can be defined as a device for opening and closing or for changing the connections of a circuit.

The classification of switching apparatus in this scope include switches, fuses, circuit breakers and contactors [3]

However, the focus is on switches since it applies to this project.

2.1.1 SWITCHES:-

The types of switches normally applied in power circuit include:-

i. Disconnecting
ii. Load interrupter
iii. Safety switches
iv. Transfer swiches for emergency power

i. DISCONNECTION SWITCHES:-

Is used for changing the connection in a circuit or for isolating a circuit or equipment from the source of power for all voltage classes. Interlocking is generally provided to prevent operation when the switch is carrying current. Latches may be required to prevent the switch from being opened by magnetic forces under heavy fault currents.

ii. AN INTERRUPTER OR LOAD-BREAK SWITCH:-

This is generally associated with unit substantion supplied from the primary distribution system, it is a switch combining the functions of disconnection switch and a load interrupter for interrupting, at rated voltage, current not exceeding the continous current rating of the switch.

iii. SAFETY SWITCHES:-

For service of 600V and below, safety switches are commonly used. These are endorsed and may be fused or infused. This type of switch is operatable by a handle from ourside the enclosure and is so interlocked that the enclosure cannot be opened inless the switch is open or the interlock thereafter is operated. The application of fused enclosed switches is limited to a current not in excess of 80% of the current rating of the same switch without fuses.

iv. AUTOMATIC TRANSFER SWICHES:- Of double throw construction used for emergency and standby power generation systems. These transfer switches do not normally incorporate over current protection. They are available in rating from 30 to 3000 amperes. For reliability most automatice transfer switches rated above 100A are mechanically held and are electrically operated from the power source to which the load is to be transfered.

These switches provides protection against failure of the utility service. In addition to utility failure, continuity of power to critical load can also be distrupted by.

a. An open circuit within the building area on the load side of the in-coming service.

b. Over load or fault condition.

c. Electrical or mechanical failure of the electric power distribution system within the building [3]

2.2 REGULATED D.C POWER SUPPLIES

If the A.C source of 230 volt is to be used to power a 12 volt Automatic change over switch or any system, a special device is required to convert the 230 volt AC to 12 volt D.C. Such a device is called 12V power supply.

It is worth mentioned here that the type of regulated DC power supply used for this project is one incorporating a step-down transformer of 220/12V ratings, a bridge rectifier. "used to convert a positively and negatively swinging voltage source to a varying voltage source whose voltage is always positive. Fig 2(a) shows the resulting output-voltage wave form when the input voltage to the rectifier is varrying sinusoidally, idea diodes are assumed in this case [4]

A capacitor to servie as the filter placed in parallel to a rectifying diode see fig.2(b).

It is assumed in this case that the reader has a reasonable knowledge about regulated DC power supply as it will not be discussed in detail in this report.

The outstanding feature of a regulated D.C power supply such as the one considered and shown in its entirety in fig. 2(c) is that the output voltage, Vo is insensitive to most circuit -parameter variations that might occur[4]

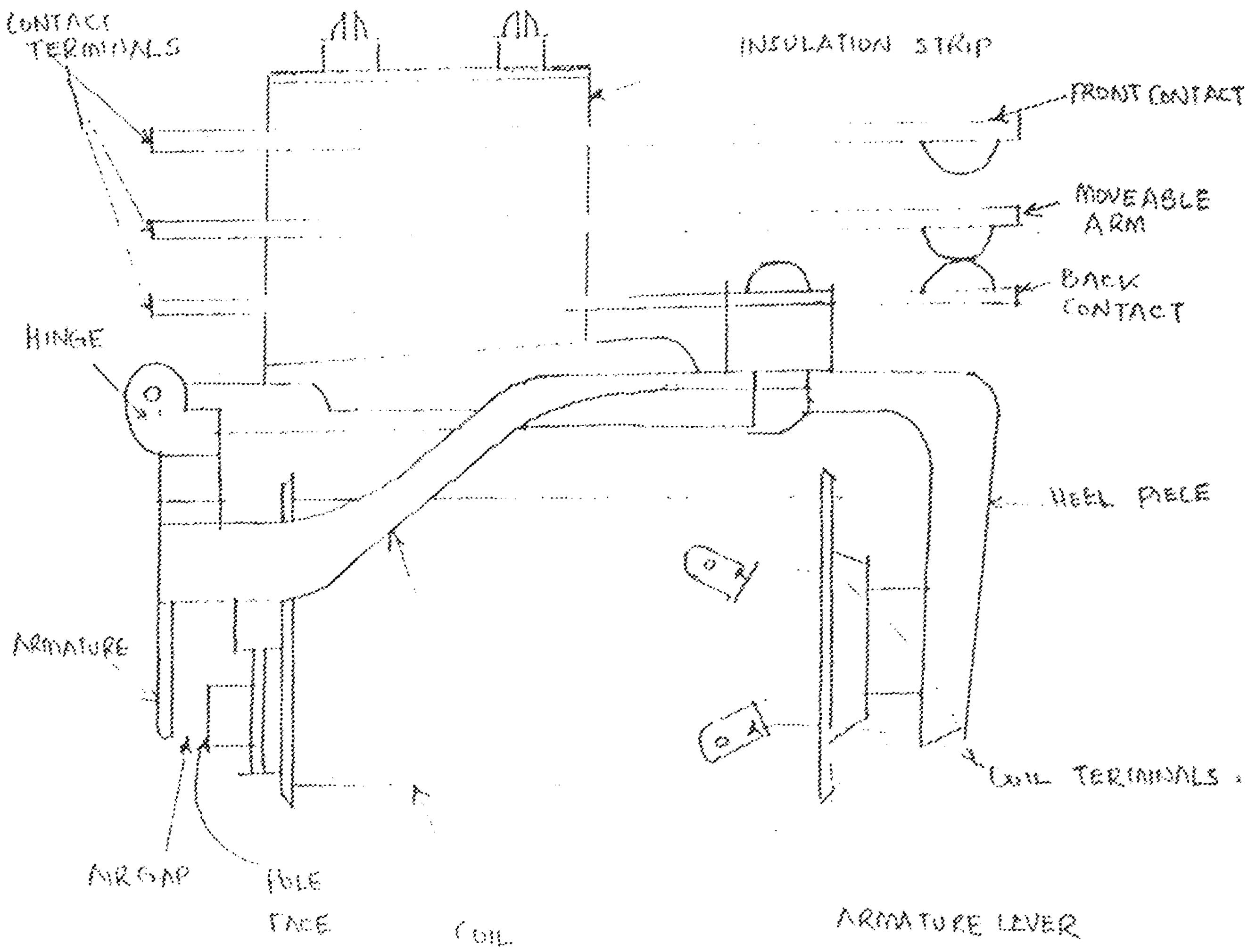


fig. 2.31(b) Structure of a conventional relay.

The most common EMR type are as follows.

i. GENERAL PURPOSE:- Design construction, operational characteristic and rating are adaptable to a wide variety of uses.

ii. LATCH IN:- Contact lock in either the energized or de-energised position until reset either manually or electrically.

iii. POLARIZED (OR POLAR):- Operation is dependent upon the polarity of the energizing current. A permanent or magnet provides the magnetic bias.

iv. DIFFERENCIAL:- Functions when the voltage current or power different between its multiple winding reaches a predetermined value.

Others types include, Telephone, stepping interlock, sequence, time delay and marginal relays [5]

The switching system is a device in the circuit that is operated automatically. The contact of a switching device is operated when current flows through the coil, this result in the attraction of the armature.

The contact found in the relay used in this project are;

i. Normally close contact (NC)

ii. Normally open contact (NO)

In this design, five (5) relays are incorporated for use into the design for the purpose of switching.

The relays was used to alternate NEPA and generator.

When NEPA is supplying power, Relays 1,2,3 and 4 are energized and their contacts closes on the mains terminal for the supply of electricity to the load. At this time, the contacts on the generator terminals are open.

However, when there is utility failure from NEPA, Relays 1,2,3 and 4 de-energized, (since no current from the rectified D.C source flows into them). The contacts of the generator terminal are closed as a result of this and the contacts of the utility line are opened.

See the circuit diagram in Fig 3.1

The electronic push switch will then start the generator and its supply will only be allowed to pass through the load by the relay concerned. This process is called an "Automatic change over switching".

The relay used have ratings of 12V and 0.03A for the coil detail and 24V, 10A for the contact detail.

2.4. ELECTRONIC PUSH SWITCH

The circuit of the electronic push switch consist of two relays (labelled 4 and 5), a capacitor C. a resistor R. and a battery.

The diagram is shown in fig 2.4

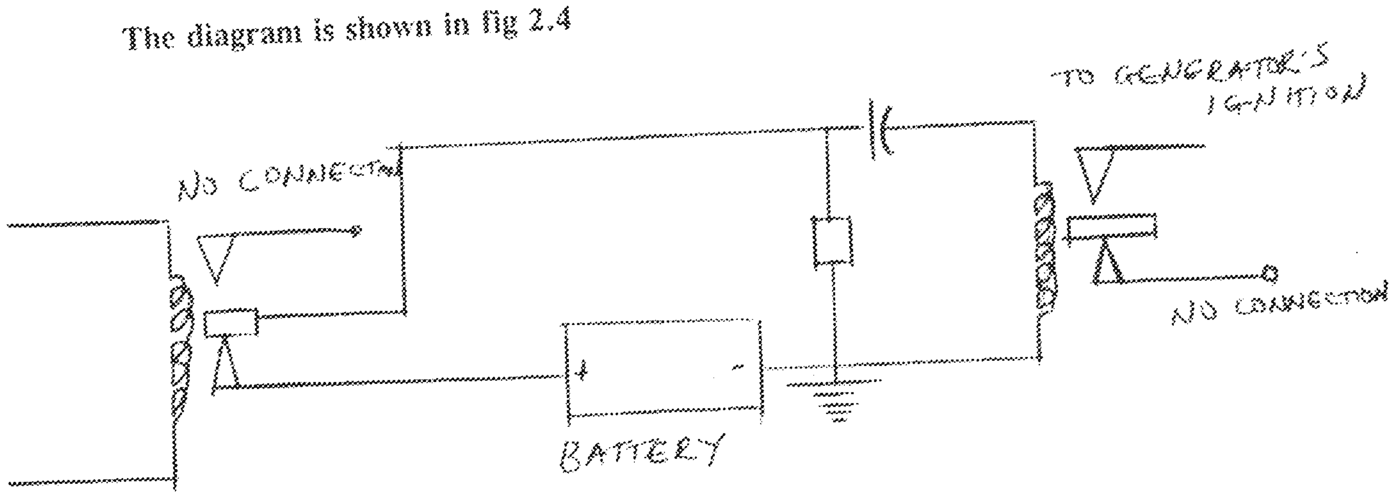


Fig 2.4 Electronic push switch

It shows a relay (5) connected in series with a capacitor, when the contact of relay (4) connected to the battery closer,relay 5 will close smartly and then open after few seconds through the contact of relay 4 still remain closed for the supply. A resistor, R. is connected across the capacitor and relay and in series to ground (i.e OV) to ensure fast reseting of the system.

To understand this, let us consider a very simple circuit with a resistor and a capacitor in parallel driven by a current source as shown in Fig 2.4.1 and assuming that the source current is constant, i (t) = I. Initially, the current is going through the short circuit, but at the time t = to switch is move from position "a" to position "b" and the cureent start of flow into the parallel combination of the resistor R, and the capacitor C, the capacitor begins to charge.

The p.d across C opposes the applied p.d. The difference between the applied p.d and the p.d across C is that which determines the chargings current, and this begins to fall in value as the p.d across C increases. When the p.d across C equals the applied p.d their difference is zero and no further current can flow. Hence, the capacitor is considered to be fully charged.

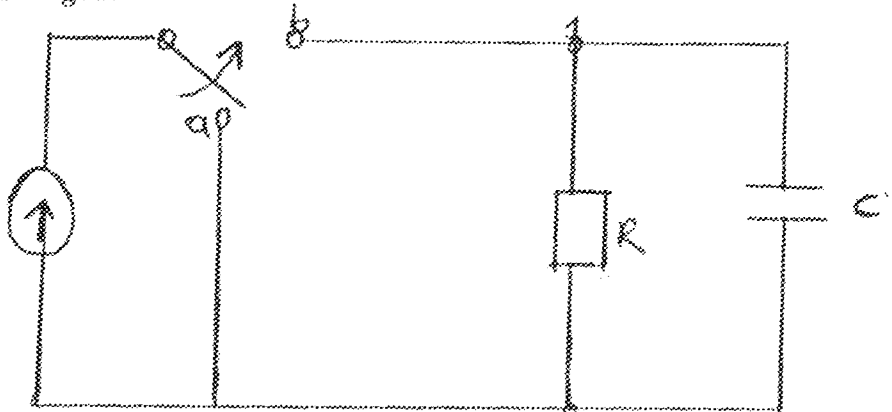


Fig. 2.4.1 parallel RC circuit driven by a current source

Based on the principle discussed, a clear understanding of Fig. 2.4.1 follows when the supply is complete, the current which flows is enough to trigger the relay since the capacitor offers little or no resistance at the begining. The current begins to decrease as the capacitor charges up and eventually, it drop below the holding current of the relay.

In this circuit, the hold-on time of the relay is the time constant (T) of the RC circuit which is.

T= RC in seconds

For the purpose of this design, 2 seconds was chosen for the hold on time of the relay after which the contact connected to the generator's ingnition opens this ensures that the ignition coil does not get burnt due to prolonged current flow. Within this time. (i.e 2 seconds) the generator should be in operation.

CHAPTER THREE

DESIGN AND CONSTRUCTION

3.1 COMPONENT DESIGN CALCULATION

3.1.1 TRANSFORMER DESIGN CALCULATION

The transformer needed for this project is a step-down transformer of 230/12V.

Considering the power of each relay, the maximum coil current that will be drawn by the relay becomes.

$V = IR$

Where $V = 12V$, $R = 400\Omega$

$I = \frac{V}{R} = \frac{12}{400} = 0.003A$

$= 3mA$

The power ratings becomes

$P = VI = 12V \times 3mA$

$= 0.36W$

Since there are four (4) relays connected on the power supply side, the power drawn by the relay becomes

$P = 4 \times 0.36 = 1.44W$

For a power factor of 0.8 and safety factor of 1.25

$COS = 0.8$

$S = VI\ Cos\phi$ where S is the complex power in VA

$S = 1.44 \times 0.8$

$= 1.152$ VA

With the safety factor of 1.25, the transformer's VA is

$1.152 \times 1.25 = 1.44$VA

A transformer of 1.44VA (or of higher rating) is needed for this design.

3.1.2 RECTIFIER DESIGN CALCULATION

A diode of peak inverse voltage (PIV) rating of 100V was chosen as the rectifier. From the data book, the diode type used is the 1N4002.

The demand diode have the following parameters

TYPES	1N 4002
Maximum reverse Voltage (VR max)	=100V
Continous forward voltage	=0.9V
Peak forward voltage	=2.3V
Max Reverse current (R max)	=50uA
Continous forward Current	=1000mA
Peak forward current	=25A

.1.4 RELAY DESIGN CALCULATION

The contact detail of the relay is found in the data book []

A printed circuit Board (PCB) mounting miniature relay with single pole change-over contacts reated at 10A,24V.D.C coil voltage is 12V. The relay is fully enclosed and contact are silver.

Coil details: 10A contact rating

Normal voltage: 12V

Coil resistance: 400Ω

Operating voltage range: 9V - 15 V

Must release voltage 1.2V

Using the contact detail of the relay, the power rating can be calculated thus;

$$P = VI$$

$$= 24 \times 10$$

$$= 240W$$

$$= 0.24.KVA$$

Coil details having the voltage of 12V for the relay and coil resistance of 400Ω, the current rating, therefore, is given as.

$$I = \frac{V}{R} = \frac{12V}{400\Omega}$$

$$= 0.03A$$

Hence, the power rating of the generator to which this project can handle is 0.24KVA with a maximum of 2.4KVA.

3.1.5 ELECTRONIC PUSH CIRCUIT CALCULATION

For the circuit, the "hold on time" of the relay is the time constant (T) which is given by the formular.

$T = RC$

Where R is the resistor value in 0hms and

C is the capacitor value in microfarad

The switching time required is 2 seconds

T = s seconds

The resistance value chosen across the circuit is

=1K0 = one kilo 0hm

Therefore the capacitor required to achieve the timing of 2 seconds is.

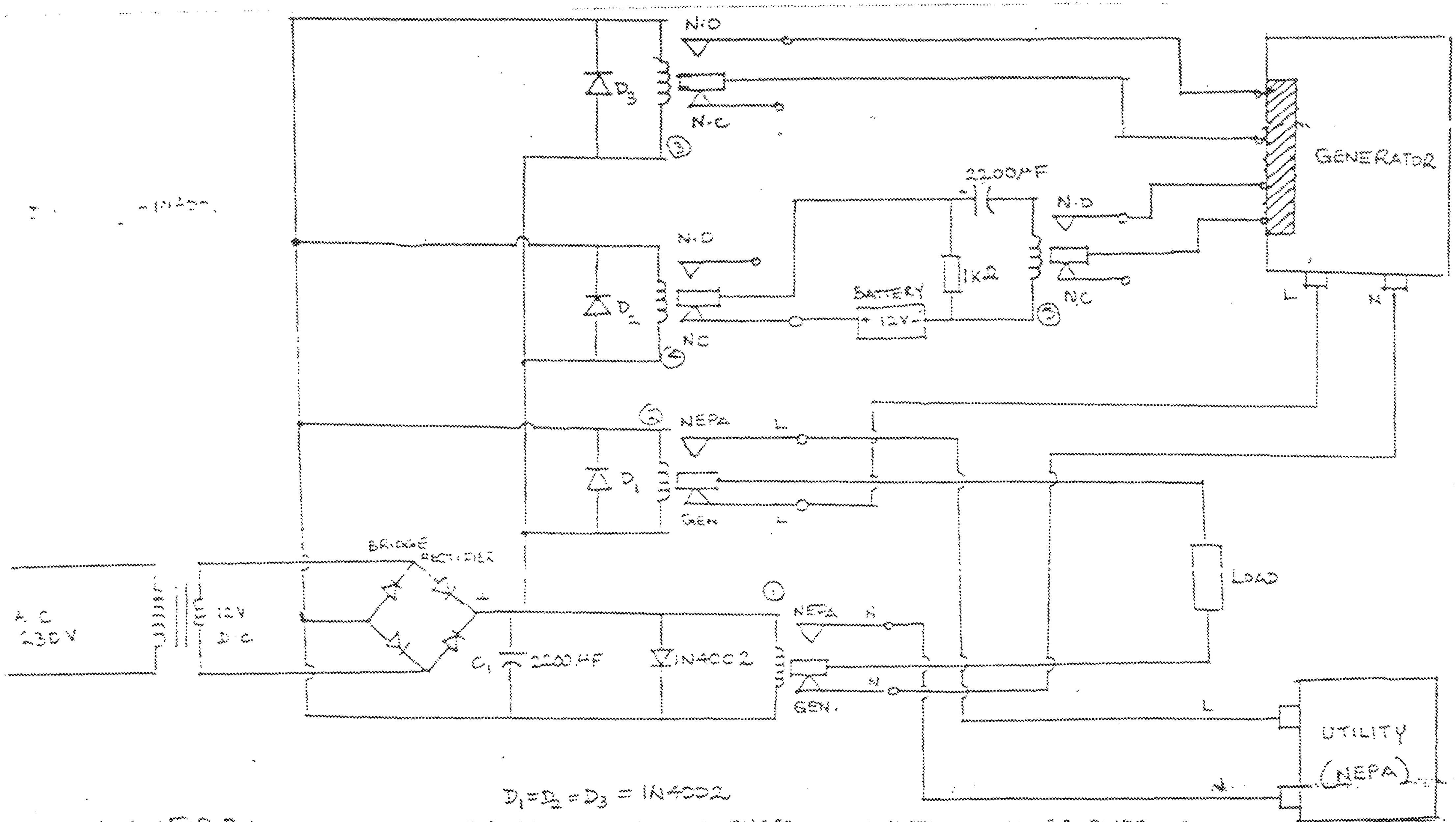
$$C = \frac{T}{R} = \frac{2S}{1000\Omega}$$

$$=0.0002f$$

$$C = 2000\mu f$$

The practical circuit closest and avialable commercial is the 2200μf and the latter was used in place of the 2000μf

See fig. 3.1 for the circuit diagram



$D_1 = D_2 = D_3 = IN4002$

FIG 3.1 CIRCUIT DIAGRAM OF SINGLE PHASE AUTOMATIC CHANGE OVER SWITCH

3.2 CONSTRUCTION

The circuit as shown in fig. 3.2 was intially built with connection to a solderless bread board, using flexible connection wires, which gives room for changes to be made if need be and for errors to be located. The system was tested and was functioning to expectation. The whole circuit was later transfered to the veroboard also known as the Electronic card where component leads were kept at a minimum, to prevent accidental short circuit. The transfer was achieved with the aid of the circuit layour. Hence, the components were mounted and soldered to the veroboard in such a manner that anybody looking at the overal circuit can easily identify different sections with ease.

In reality, the construction was carried out in stages with the 240/12 volts transformer being the first component fixed. The rectifier and its accessories called the rectifier circuit was next to mount. The output voltage of the rectifier, powers the relays by giving it different current of 12Volt, which is uses to change over the contact of the relay.

The electronic push switch was mounted as well.

PRECAUTION TAKEN DURING THE CONSTRUCTION

The precaution taken during the construction were as follows:-

i. The bread board was extensively used for the text construction

ii. The power supply unit was normally put off from the circuit when mounting or removing components during the text construction on the bread board.

iii. The vero bread was carefully checked and tested for continuity.

iv. Re-checks were made more often to ascertain the right position of components and jumper wires.

v. Off-target solder splashes were carefully removed to avoid short-circuiting.

vi. Care was taken during soldering of the component to avoid over heating.

3.3 CASING AND PACKAGING

The casing of the project is made of wood which was used for the purpose of a adjustments in terms of its length or breadth or height see fig. 3.21 for the casing's shape and dimension. Holes were thereafter, drilled on surface of interest, the case was afterwards assembled.

The circuit was packaged into the case on the basic of available space. Connections were taken out of the holes that were drilled examples are the power cable of this project, the battery terminal input, ignition input as well as the input from the Generator and the utility (NEPA) and the load output were connected to three (3) 13A socket respectively.

Three light emiting diodes with colours Red, amble and green are indicators for NEPA, ignition and Generator respectively.

For a big generator having power rating of up to 24KVA or higher, this project can be improved to meet its requirement. This is accomplished by using high current rating relay.

CHAPTER FOUR

TEST RESULT AND DISCUSSION OF RESULT

4.1 TEST,

This project was tested by connecting power cable plug to the socket from the utility. And also the source from NEPA to the NEPA input of the project. The ignition terminals were connected to a multimeter, and a battery (12VDC) was inturn connected to the terminals of the battery input of the project.

Thought a generator was not available to test with, however the generator input was connected to anohter 12VDC battery.

When NEPA was supplying, the plug to NEPA supply was switched on. The indicator shows that NEPA is supplying the load.

When NEPA source was switched off and the NEPA input of the project was switched off, the multimeter deflected for about 2 seconds and then returned back to its initial position of null deflection. This indicator that the ignition was made to allow the generator supply itspower. The multimeter's deflection for 2 seconds and returning back to its original state indicate the ignition was made immediately NEPA went off and then dis-engages the Generator. This is to ensure that the ignition coil is not destroyed due to continous passage of current through it. By this time, it is expected that the generator is running and would have been supplying power to the load.

By switching on the second power from another phase connected to the generator input terminal, the generator glowed showing that the generator was supplying.

4.2 RESULT

The real time it took the ignition to come 'on' and dis-engage was about 1-second. Ten test were carried out and can be seen in the table below.

TABLE 4.1

NUMBER OF TEST	TIME IN SECONDS
1	1.60
2	1.80
3	1.60
4	1.60
5	1.70
6	1.60
7	1.60
8	1.60
9	1.40
10	1.30

Average is 1.6 seconds

This was due to the value of the capacitor used since there was no practical capacity of the value 2000micro Farad, therefore a 2200 micro farad capacitor was used, hence the result.

4.3 DISCUSSION OF RESULT

The project has been designed and constructed not without hitches. However, the aims of the project was achieved.

The institution of Electrical Engineering (IEE) regulation stipulates that; For the safe utilization of electrical energy, the fluctuation about normal voltage at anytime must not exceed $\pm 6\%$.

In Nigeria, the normal domestic supply voltage (i.e for a single phase, line to Neutral) is 220V. By interpretation, it means that the supply voltage is

$$\frac{6 \text{ X } 220}{100} = 13.2$$

$\pm$ 13.2V of 220V are

(220.13.2)V =206.8V

and

220 + 13.2 =233.2

The supply voltage to this project, therefore, should be in the range of 206.8V approximately 207V to 233V. From this regulation, it shows that the project is safe to be applied to sensitive domestic and industrial establishment. (On single phase appliance so rated).

CALCULATION FOR THE RELIABILITY OF THE SYSTEM USING

FAULT TREE ANALYSIS

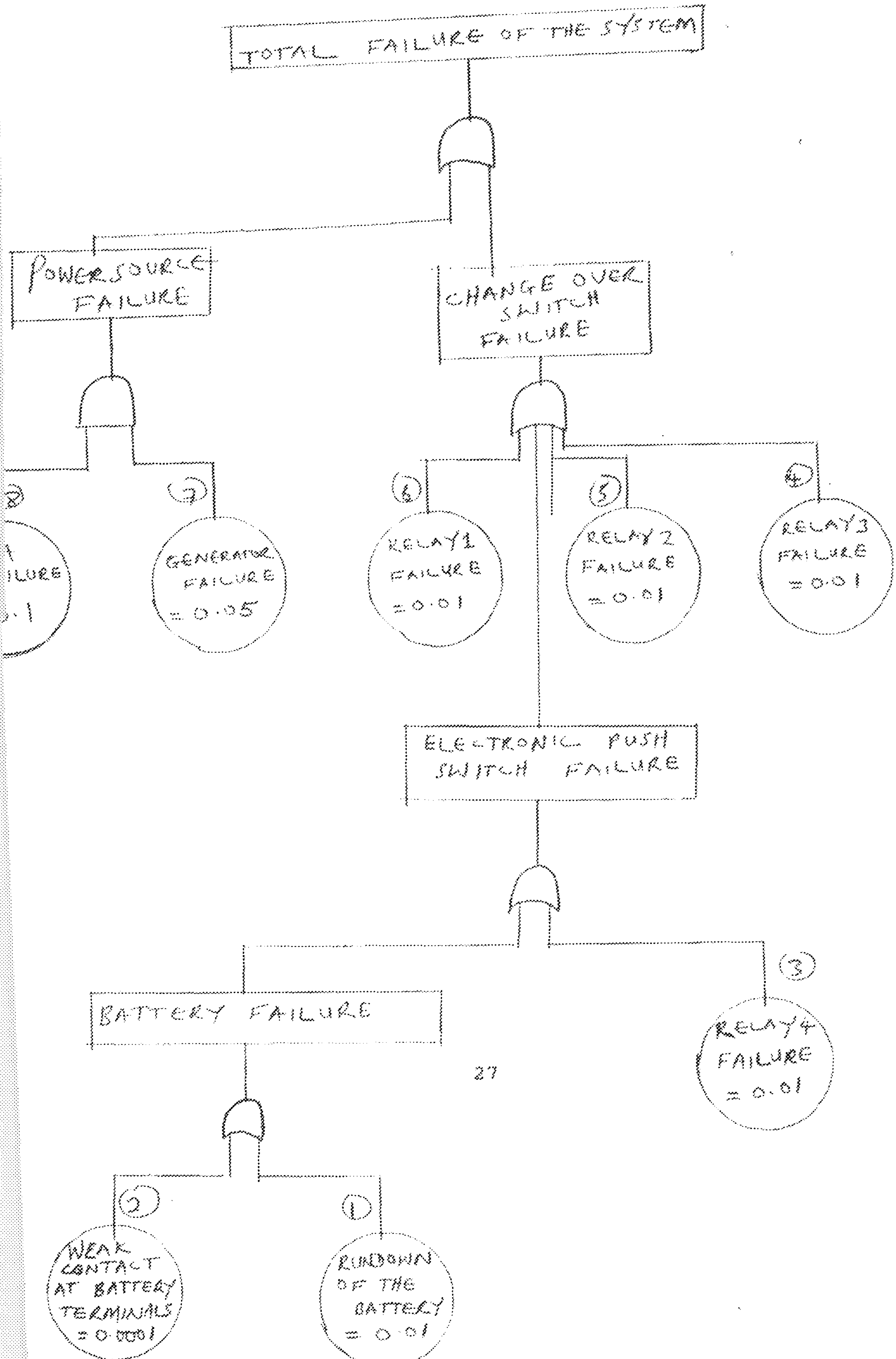


Fig 4.3 Fault tree diagram

RELIABILITY:- Reliability of a system is the probability that the system will function within specified limit for at least a specified period of time under specified environmental condition.

-Represent AND and it is used for parallel connection in the Fault Tree Analysis.

-Represent OR, and it is used for serial connection.

ANALYSIS

Probability of Battery failure

= 1 - (1-0.0001) (1-0.01)

= 0.0101

Probability of Electronic push switch failing.

= 1 - [(1-0.0101) (1-0.02)]

= 0.02

Probability of change over failing is

= 1-[(1-0.01) (1-0.02)]

Probability of change over failing

= 0.0491

Probability of power source failure

= (0.1) (0.05)

= 0.055

Probability of Total Failure

$= 1- [(1-0.05)\ (1-0491)]$

$= 0.054$

F(t) which is the Failure probability of a system is

$F(t) = 0.054$

The Reliability of the system is given by the formular

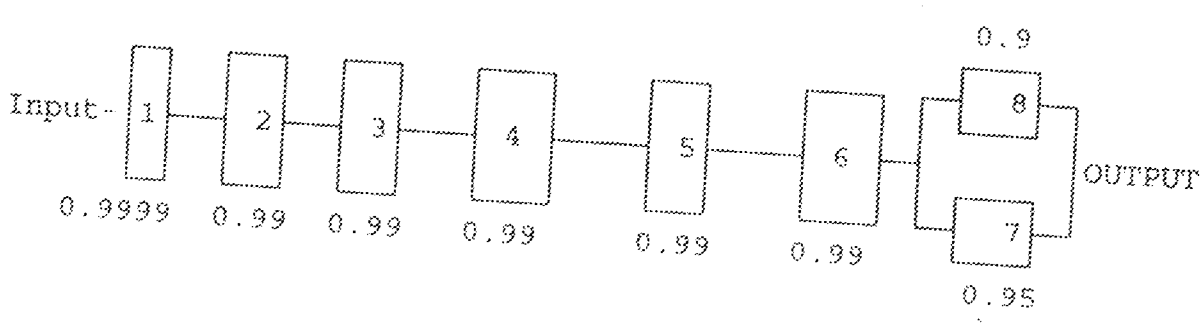
$R(t) = 1 - F(t)$

$R(t) = 1-0.054$

$R(t) = 0.946$

From this result, it shows that the system is highly reliable. Since 1 indicates that system is highly efficient and reliable.

From this, the reliability block diagram can be drawn.



Probability of Total Failure

$$= 1- [(1-0.05)\ (1-0491)]$$

$$= 0.054$$

F(t) which is the Failure probability of a system is

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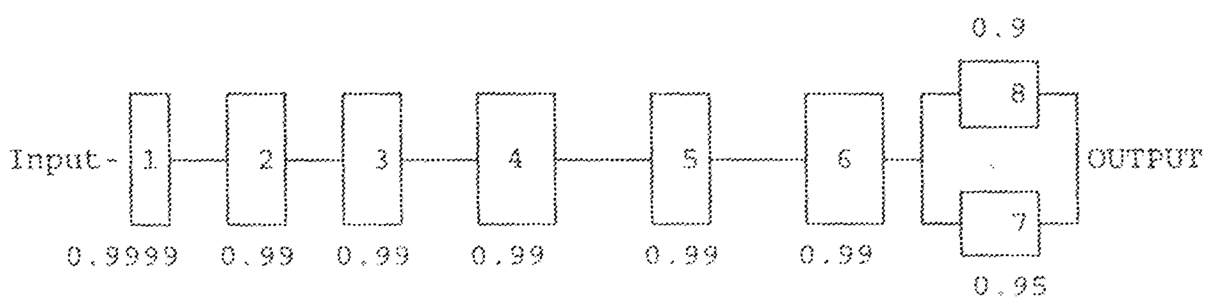

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The design and construction of an automatic change over switch has not been without its own problems. The problem encountered were in the area of the electronic push switch since precision is need for the project to function as expected. It is worthy of note that the capacitor which is suppose to be used was not available since there was no practical value of such. However, a closer value of capacitor was used hence the reduction in time from the time required.

For a relay to function properly, there must be a good working control unit put in place and this was achieved by selecting the right value of components while building the project.

It is also important to know the power rating of the generator that is intended to be used as an alternative power source before considering the relays to use in designing this project. For this design, 10A relays were used, as a result, a generator with a rating higher than 2.4 KVA cannot be used since this will damage the contact of the relay.

In conclusion, the purpose of the project was achieved not without some difficulties encountered during the construction and testing.

The system is also reliable with a value of 0.946 that is, it is 94.6% efficient.

5.2 RECOMMENDATION

For the project to carry a higher power rating generator, the project has to be modified. This includes the uses of relays of higher current rating since the contact rating of the relay is the major determinant of the performance of the system.

It is recommended also that the contact rating of the relay be slighty higher than the equipment it is intended to be used for.

Also, any student or person who is intending to carry out this project is expected to have basic knowledge of electronics and be albe to apply them.

I will also want ro recommend that the number of student under a particular supervisor be reduced drastically, this is to ensure that the supervisor has adequate time to these students and hence proper supervision.

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