DESIGN AND CONSTRUCTION OF A SINGLE PHASE AUTOMATIC PHASE CHANGE OVER SWITCH

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'ROJECT SUBMITTED FOR THE AWARD OF ɪACHELOR OF ENGINEERING (B.ENG) DEGREE IN THE :LECTRICAL / COMPUTER DEPARTMENT OF THE 'EDERAL UNIVERSITY OF TECHNOLOGY, MINNA-ɪIGER STATE, NIGERIA.

NOVEMBER 2005

DECLARATION

I hereby declare that this project (AUTOMATIC PHASE CHANGE OVER SWITCH) was constructed by me under the supervision of Engr. M.S. Ahmed, a lecturer in the department of electrical / computer engineering, Federal university of technology, Minna.

.... .30/11/05..

AGUSIOBO O.B **Date**

Student

CERTIFICATION

his is to certify that this project **(AUTOMATIC PHASE CHANGE OVER SWITCH)** was esigned by Agusiobo O.B for the award of Bachelor degree in electrical/computer engineering, ederal university of technology, Minna Niger State.

.... 30/4/05

ENGR. M.S. Ahmed **Date**

PROJECT SUPERVISOR

.... 27/03/06

ENGR. M.D. ABDULLAHI **Date**

H.O.D

....

EXTERNAL EXAMINER **Date**

DEDICATION

This project is dedicated to almighty God who saw me through my course of study and especially through this project work and then to my Parents Engr. and Mrs. R.O.C AGUSIOBO.

ACKNOWLEDGEMENT

Thanks be to almighty God who made it possible for me to carry out this project work successfully.

My profound gratitude goes to my parents Engr. and Mrs. R.O.C Agusiobo for their dedicated effort to see through my Academic pursuit from Primary School till date.

My thanks also goes to my Supervisor Engr. M.S. Ahmed for his assistance, Recommendation, Suggestion and time given to me during my project work. I also say thanks to the Head of Department and all the Lecturers of Electrical/ Computer Engineering Department for Knowledge they impacted on me.

My special gratitude goes to all my family members, my friends, Shehu Zibiri and most especially Moyo Ogunsote for their support and encouragement.

ABSTRACT

Most industrial and commercial process are dependent on power supply and if the processes of change over is manual, serious time is not only wasted but also creates device or machine damage from human error (In the area of change over connections) which could bring massive cash losses.

This project is the design and construction of an automatic phase changer switch that switches power supply if power supply fails from power holding company of Nigeria (PHCN) to generator, once there is power outage or a low voltage. The project uses an electronic control circuit involving integrated circuits (ICs), transistor and electromechanical devices. The ICs senses when the voltage is LOW and switches the relay via a transistor switching circuit to change over from PHCN to GENERATOR.

In this project, supply voltage of +5 (V) dc and +12 (V) dc with input voltage of 220 (V) ac – 240 (V) ac transformer and change over voltage of 170 (V) ac were used. Based on this project, the maximum power rating capacity was found to be 6 KVA.

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CHAPTER ONE

GENERAL INTRODUCTION

1.0 Introduction

Research in the field of Electrical Electronics has led to tremendous discoveries and inventions especially in the areas of automation and power control. These inventions has been useful in solving the ever increasing problems posed by power generation, distribution and control which have been a cause of concern especially in Third World Countries. The nature of power instability in Nigeria (for instance) creates a need for automation of power generation or alternative sources of power to back up the utility supply. This automation is required as the rate of power outage becomes predominantly high. Most industrial and commercial process are dependent on power supply and if the processes of change over is manual, serious time is not only wasted but also creates device or machine damage from human error (In the area of change over connections) which could bring massive cash losses.

This project is the design and construction of an automatic phase changer switch that switches power supply if power supply fails from power holding company of Nigeria (PHCN) to generator, once there is power outage or a low voltage. The project uses an electronic control circuit involving integrated circuits (ICs), transistor and electromechanical devices. The ICs senses when the voltage is LOW and switches the relay via a transistor switching circuit to change over from PHCN to GENERATOR.

The starting of the generator is done by another relay which switches the battery voltage to ignition coil of the generator while the main power relay switches the load to either PHCN or GENERATOR. The advantages of this project cannot be overemphasized, as power outage is a major problem in Nigeria. A power failure of minutes in an airport terminal for instance can create losses that could run into millions due to air traffic systems control. The ability for a backup to start and change over automatically becomes imperative under such circumstances. Also this system could play a large role in security systems in banks and companies. An outage of up to 10 minutes in an organized set up is enough to do all the damage required, with an automatic change over in place, the generator back-up will no longer depend on men.

Fig 1.0 below shows the generalized block diagram of the project

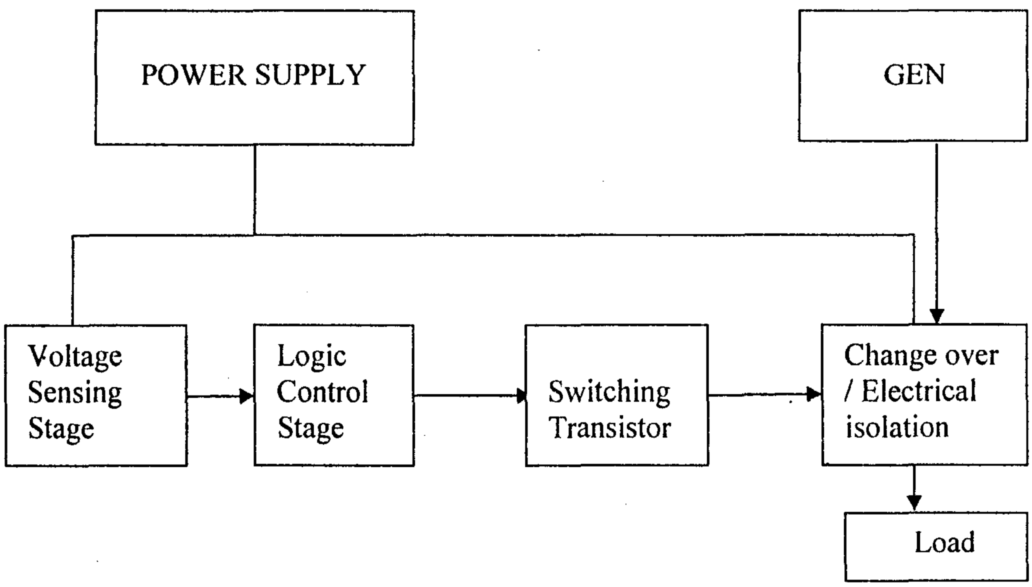

Fig 1.0 Block Diagram of an automatic change over switch

1.2 Design Specifications.

SUPPLY VOLTAGE:	+5 V DC and +12 V DC.
INPUT VOLTAGE:	220V AC – 240V AC.
CHANGE OVER VOLTAGE:	170V AC.
MAXIMUM POWER:	6 KVA.
STARTER VOLTAGE:	12 V DC.

CHAPTER 2

2.0 LITERATURE REVIEW

A manual change over switch consists of a manual change over switch box, switch gear box and cut-out fuse or the connector fuse. This change over switch box separate the source between the generator and Power Holding Company of Nigeria (PHCN) and when there is power supply outage from PHCN, someone has to go and change the line from PHCN source to generator. Thus when power supply is restored from PHCN someone has to put OFF the generator and then change the source line from generator to PHCN.

The switchgear is used to protect the equipment of the generator as well as that of the building. This shows that if there is high voltage from PHCN the fuse inside the switchgear will cut-off. This separates the supply from the load; this also does the same when there is high voltage from the generator. The cut-off is an additional protector of any high voltage between PHCN source and the switch gear.

In view of the above manual change over switch system that involves manpower by using ones energy in starting the generator and switching over from PHCN to generator and vice-versa when the supply is restored by PHCN. The importance attached to cases of operation in hospitals and air ports in order to save life from generator as fast as possible makes it important for the design and construction of an automatic change over switch which would solve the problem of manpower and the danger likely to be encountered.

In this project, supply voltage of +5 (V) dc and +12 (V) dc with input voltage of 220 (V) ac – 240 (V) ac transformer and change over voltage of 170 (V) ac were used. Based on this project, the maximum power rating capacity was found to be 6 KVA.

CHAPTER 3

3.0 DESIGN AND ANALYSIS

3.1 Principle of Operation

The operation of the project involves an electronic control and an electromechanically control changeover. The electronic control monitors the incoming PHCN voltage and detects when the voltage drops below a level where electrical or electronics gadgets cannot tolerate depending on the utility supply (PHCN).

In this case 160v is the limit, which the system charges over from PHCN or generator. The sensor stage monitors the unregulated voltage dropped across R1 and R2 (as shown in fig. 3.1 for comprehensive circuit diagram also as in fig 3.5).

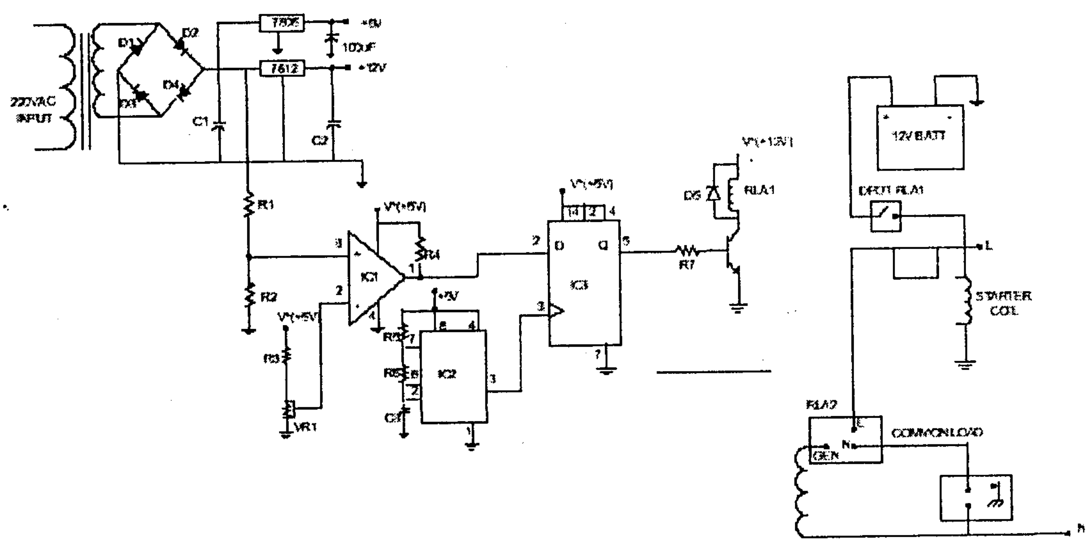

fig 3.1 comprehensive circuit diagram

The voltage feeds an input on IC1 which compares this input with a fixed reference across VR1. The drop across R1 at 160v ac is set as the reference. Any voltage drop below this sends a LOW to the input of the D-flip flop to switch the transistor OFF in set mode. Once the transistor I switch OFF, the relay is de-energized and the contacts changeover. Two relays are connected in parallel RLA1 is a 10A relay which switches the BATTERY 12V to the ignitions coil (or starter coil) of the GEN., and switches it OFF once PHCN supply is back .The second relay RLA2 is a 30A relay that selects GENERATOR or PHCN output to load.

The generator output is the normally closed hence, once de-energized, the generator output is fed to LOAD and once energized (by the presence of PHCN) the relay ONs (normally open contact, connects PHCN output to LOAD).

The introduction of the 7474-segment logic device is to ensure perfect switching and eliminate hysterics problem, which is synonymous with voltage comparators. This could be very devastating, as the relays would be switching erratically.

The switching stage switches the relay contact ON and OFF in the presence and absence of the PHCN voltage. The output change-over power is determined by the relay contact ratings.

3.1.2 Comparator /Voltage Sensor Stage

The function of the comparator is to compare two voltages and give an output, which tell if they are equal or unequal. The comparator stage in this project is used to sense when the PHCN voltage has dropped below a certain level. The input PHCN voltage is converted to DC in the power supply stage and regulated to 12V and 5V for the power supply needed in the circuit. The unregulated voltage varies as the PHCN input varies. Table 1.1 shows the variation in DC voltage against the input PHCN voltage.

Table 3.1 variation of Dc voltage against input PHCN voltage

AC INPUT	V_{unreg} (d.c)	VR_2 (d.c)
240	19	2.1V
230	18	2.0V
220	17	1.9V
210	16	1.8V
200	15	1.7V
190	14	1.6V
180	13	1.5V
170	12	1.4V
160	11	1.3V
150	10	1.2V

V_{unreg} = unregulated d.c voltage

VR2(d.c)= drop across R2

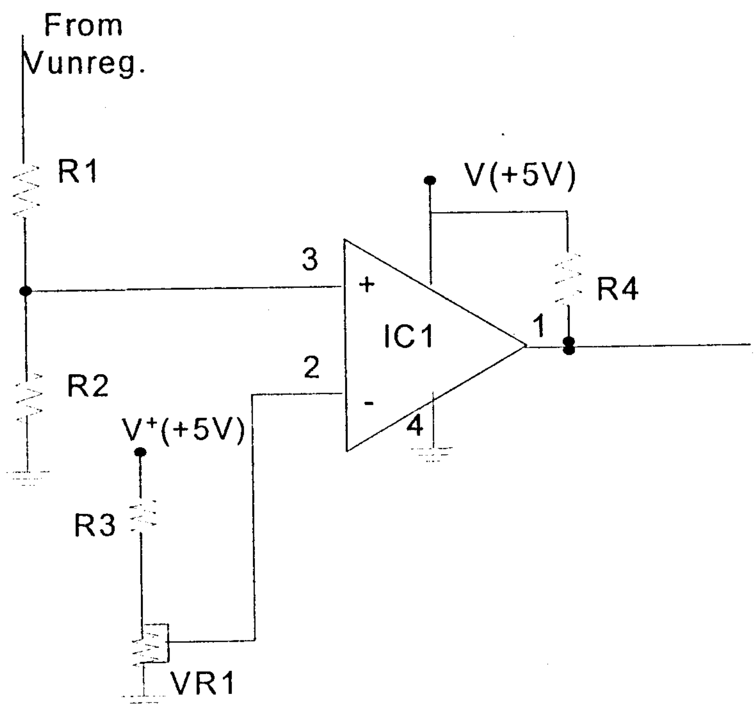

fig 3.2 comparator stage.

3.1.3 Design Calculations.

R_1 and R_2 form a potential divider. To drop the unregulated voltage to a low voltage below 5v. At 160V ac input let VR2 = 1.5V

But $VR_2 = R_2/(R_1+R_2) \times V^+$ ....(1)

Where VR_2 is the drop across R_2 and V^+ is the unregulated voltage. From table 3.1 it can be seen that $V^+ = 11V$ at 160VAC input.

letting $R_1 = 100k$

$1.5V = R_2/(100K+R_2) \times 11$

$150K + 1.5R_2 = 11R_2$

$150K = 9.5R2$

$R_2 = 150k/9.5$

$= 15.7k$

$= 15k$ preferred value

$R_1 = 100k$, $R_2 = 15k$

R_3 and R_4 form another potential divider for the reference. Letting a maximum adjustable reference of 3.5v and setting $R_3 = 1.5k$

$VR4 = R_4/(R_4+R_3) \times V+$ (where $V^+ = 5v$)

$3.5V = R_4/(R_4 + 1.5k) \times V+$

$3.5 R4 + 5.25 = 5R_4$

$5.25 = 1.5R_4$

$R_4 = 5/1.5$

$= 3.5kv$

$= 5kv$ preset (preferred value)

$R_3 = 1.5kv$ and $R_4 = 5kv$ preset.

For the comparator,

$Vout = A_0 Vin$

Where A_0 = open loop voltage gain. (Usually 20,000 or more).

And $Vin = V^+ - V^-$

Vout will drop to V+ for the slightest positive difference in voltage since A_0 is often very large (in order of 20000).

As the PHCN input drops below 1.5V reference, the output of the comparator goes LOW to change over the relay. As the output tends goes above 1.5V, the output of the comparator goes HIGH to switch PHCN to the output.

3.2 Astable Oscillator

The flip-flop is a synchronous device and requires clock pulse to operate in its SET and RESET modes. The astable oscillator stage of 1KHz using a 555 timer is used to clock the flip-flop. Fig 3.3 shows the 555 timer oscillator stage.

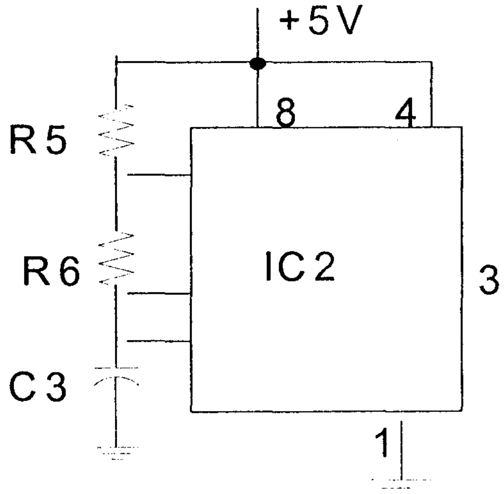

fig 3.3 astable oscillator stage

3.2.1 Design Calculations

$t_1 = 1.1\ C(R_1 + R_2)$ seconds (where t_1 = ON time)

$t_2 = 0.693CR_2$ seconds (where t_2 is the OFF time)

Since $F = 1/T$

& $T = t_1 + t_2$

$F = 1/\ \ln 2C\ (R_1 + 2R_2)$ seconds

$F = 1.44/(R_1 + 2R_2)C$ ....(1)

Letting R1 = 5.1K and C = 47nF for F=1KHz)

Substituting the values into equation 1

R_2 =12.7K

=12K preferred value.

Hence, R5= 5.1k, R6=12K and C3=47nF.

3.3 Flip Flop/ Switching Transistor Stage.

The flip-flop acts as a logic control while the transistor acts as a switching circuit. Fig 3.4 shows the circuit diagram of the flip-flop and switching transistor stage.

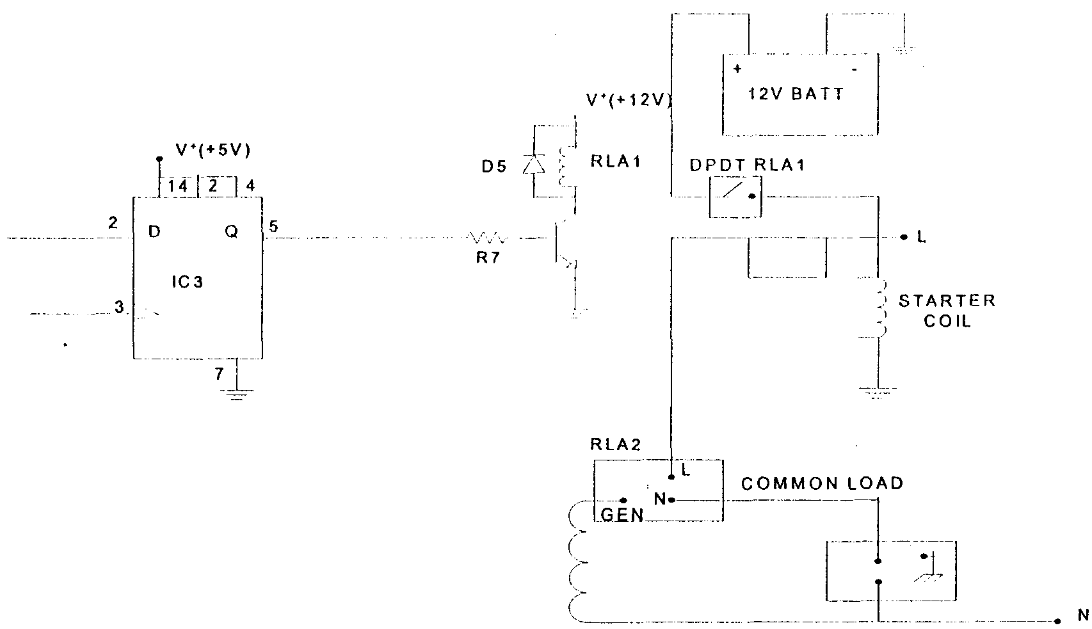

Fig 3.4 the circuit diagram of the flip-flop and switching transistor stage.

3.3.1 Logic Control

The logic control is built around a D- type flip-flop. It is the flip-flop that tells the system when to switch to generator or PHCN. The operation of the system is described in the truth table below.

Table 3.2 Flip Flop Truth table

Mode	D input	Ck	Q	Q	R
Set	1		1	0	1
Reset	0	X	0	1	1
Hold	X	X	0	1	0

X …… Don't care

… Rising edge

Q and Q …... Outputs

D …..:. Data input

The logic control circuit operates in its set and reset mode. When the rising edge of the astable clocks the flip-flop, the flip-flop shifts data from the data (D) input to the Q output to OFF the generator and connect PHCN to output. When the voltage drops the comparator sends a LOW to the flip-flop input which switches the generator ON and changes over the output to generator.

3.4 Transistor Switching Circuit.

The switching transistor switches the relay, which selects between the GENERATOR AND PHCN. The transistor as a switch operates in class A mode. The relay is switched on when the flip-flop is in SET mode. A base resistor is required to ensure perfect switching of the transistor in saturation. Diode D5 protects the transistor from back emf that might be generated since the relay coil presents an inductive load.

In this case Rc, which is the collector resistance, is the resistance of the relay coil, which is 400Ω for the relay type used in this project. Hence, given that Rc = 400Ω (Relay coil resistance)

$V^+ = 12V$ (regulated voltage from the power supply stage)

Vbe = 0.6V (silicon)

Vce = 0V (when transistor is switched)

Vin = 5V (from the flip flop stage)

Hfe = 300 (from data sheet for BC337)

since,

$V_+ = I_c R_c + V_{CE}$ ---------------------(1.0)

$V_{in} = I_B R_B + V_{BE}$ ---------------(2.0)

$I_C / I_B = h_{fe}$ ---------------(3.0)

$R_b = V_{in} - V_{BE}/I_B$ -----------------(4.0)

Where,

I_C = collector current

I_B = base current

V_{in} = input voltage

V_t = supply voltage

V_{CE} = collector-emitter voltage

H_{fe} = current gain.

From 1.0, $12 = IcRc + Vce$

$12 = Ic(400) + 0$

and, $Ic = 30mA$

From 3.0, $I_B = 30mA/300$

$= 100uA$

From 2.0, $5V = 100uAR_B + 0.6$

$R_B = 4.4/100uA$

$= 44K\Omega$

$= 47K\Omega$ (preferred value)

3.5 Comprehensive Circuit Diagram.

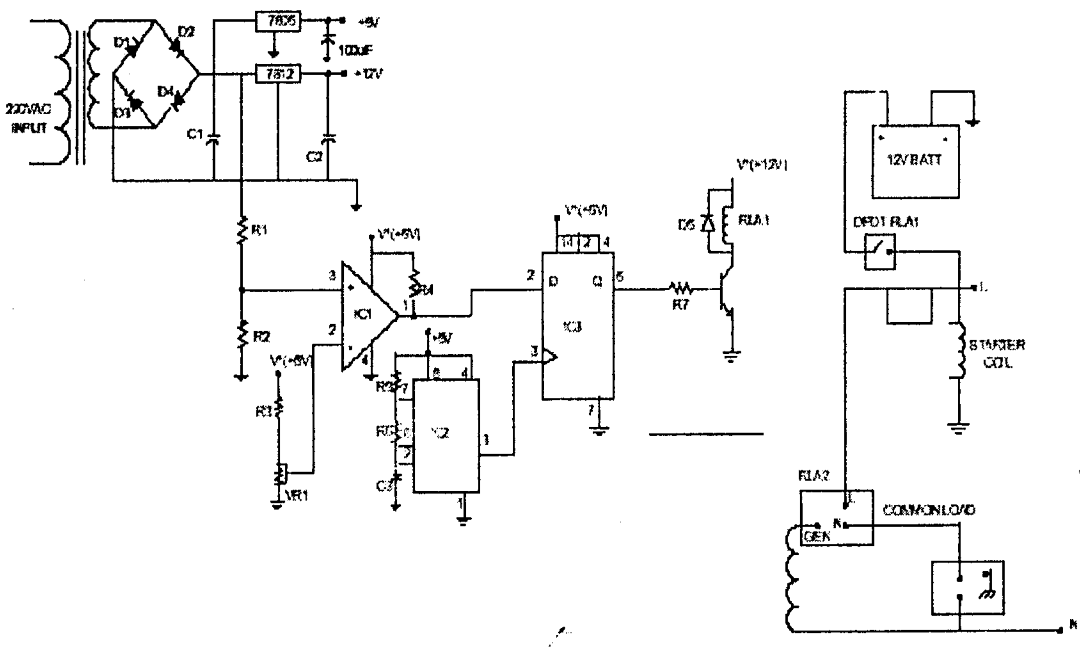

Fig 3.5 Comprehensive Circuit Diagram.

CHAPTER FOUR

4.0 CONSTRUCTION TESTING AND RESULTS.

Some of the tools for the construction are, side cutter, precision set, screw driver, tester, blade, needle – like driller and some of the materials include; Vero board, 12V battery, connectors, connecting wires, a lamp holder and one electric bulb, relays, capacitors, a light emitting diode, a transformer, a voltage regulator of 12V, a cable of 1.5mm diameter, plug heads and a digital meter.

4.1 Component List

R1 - 100K

R2 - 15K

R3 - 1.5K

R4 - 5K preset

R5 - 5.1K

R6 - 12K

R7 - 47K

C1 – 3300μF

C2 – 100μf

C3 - 47nF

IC1 - LM393

IC2 - NE555

IC3 - 7474

RLA1 - 10A, 12V

RLA2 - 30A, 12V

4.2 CONSTRUCTION DETAILS

The circuit layout was carefully planned and each section of the bread board was easily identified. The circuit was first built on the solderless bread board, it was latter transferred to the Vero board.

The first component fixed was the transformer step down of 240/18V. A positive voltage regulator of 12V was then used after rectification by the rectifiers and a filtering capacitor to stabilize the d.c voltage at 12V so used to activate the relays. The regulator was used in building the power supply to allow for easy adjustment and self protection against short circuits. The mounting of the electronic push switch circuit was done in good manner.

4.3 PREVENTIVE MEASURES TAKEN

1. The entire components were tested before use to ensure that they are in good working order.

2. Polarities of the components were considered before connecting them to prevent components damage.

3. The Normal open and close of the relay were identified with the aid of a digital meter to avoid wrong connection of the relay contacts.

4. Badly soldered joints were avoided by applying a little solder into the joints.

5. Water and moisture were prevented from coming in contact with the circuit build.

4.4 TESTING AND RESULT

When all the soldering had been done on the Vero board the whole circuit was traced to ensure that there is no short or open circuit. The output of the power supply unit which powers the relays was tested by making the relays to change over immediately the power is supplied.

In absence of a generator, the project was tested with two PHCN sources: one representing a generator and the other representing PHCN source. One electric bulb was used for the testing. When the supply of PHCN is ON and the source of the generator OFF the bulb which is the load lights, when the source of PHCN is OFF and the one for generator switched ON the load which is the bulb lights.

4.5 PROJECT CASING

Any equipment needs a container to protect it and make it safe for use. The casing unit of the project constructed, is made of a rectangular shaped box.

4.6 PROBLEMS ENCOUNTERED

Initially, the voltage across the Regulator was not up to the required 12V when measured until the circuit was trouble shooted also when powered in the first instance, some of the relays coils got burnt and could not change contacts. This is a result of some points along the Vero board not properly isolated to prevent short circuiting. This was later corrected and the circuit attains normalcy.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

From the foregoing section it can be seen that the design and construction of a Automatic Phase Change Over Switch just like any other project work requires planning and implementation. This project work has been a very challenging task. The project has given me the opportunity of getting a better understanding of some basic electronic principle and implementing practically .The problem of getting the necessary textbook for research construction and report write up had to be contented with. Even with this most of the construction and project write up was carried out through painstaking research.

The design and construction of Automatic Phase Change Over Switch has successfully being constructed as explained in chapter three of this project write up. From the various test carried out and the result obtained, it has shown however that the aim of the project as stated in chapter one of this write up has been achieved and since the principle used for the project worked accordingly to specification and quite satisfactory.

Automatic phase Change Over Switch is relatively affordable reliable, easier to operate and provide high level of Power supply when there is power outage and it reduces stress for man power change over.

5.2 RECOMMENDATION

The following suggestions are given on the project work generally. I recommend that the department should help students in their project work and that project should be given to student before they go on the Industrial Attachment program so as to make them have broader view and research widely on their project.

(1) I also recommend that this project Automatic Phase Change Over Switch be used in, multinational companies, Hospitals, Banks, Schools, Military System, Tertiary Institutions.

Since the design can still be improved on, the following suggestions listed below were made to serve a basis (guide) for further research in this project in the improvement of this project design work.

In this project, supply voltage of +5 (V) dc and +12 (V) dc with input voltage of 220 (V) ac to 240 (V) ac transformer and change over voltage of 170 (V) ac were used. Based on this project, the maximum power rating capacity was found to be 6 KVA. To be able to use a higher rating generator, the design has to be modified. Higher contact rating relays can be used for further improvement.

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