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DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيم

THESIS ON

AUTOMATIC GENERATOR START AND CHANGE OVER MODULE

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This is to certify that the work presented in this thesis is an outcome of the investigation carried out by authors under the supervision of Dr.khazi Khari Islam professor at the Dept. of EEE in Islamic university of technology (IUT).

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CHAPTER ONE: INTRODUCTION

McGraw-Hill, 1998 stated that “automatia” (Ancient Greek: self dictated) is the use of control system to control industrial machinery and process, replacing human operator. In the scope of industrialization, it is a step beyond mechanization, whereas mechanization provided human operators with machinery to assist them with physical requirement to work. Automation greatly reduces the need for human sensory and mental requirement as well.

1.1 GENERAL INTRODUCTION

Standby power generator is a key component of a high availability power system for data centres and network rooms. Information technology systems may work for one minute or even a few hours on battery, but local power generation capability is the key to achieving high availability. In locations with poor utility power, local power generation may be needed to achieve even a minimal requirement of 99.9%

availability. Generator systems with diesel or natural gas engines are in most cases the solution for standby power generation. A generator system includes not only the standby generator but also the automatic transformer switch (A.T.C), the output distribution and management system. The A.T.S is fed by two sources, the utility and the generator, with the utility being the preferred source. When the preferred source is inaccessible, the A.T.S automatically switches to the generator.

1.2 OBJECTIVES

Engineering effort is primarily concerned with the design of equipment by which people can utilize power. The design of new devices with greater usefulness and capabilities is bringing about an ever increasing growth in the development of switching requirements. The reason is in many folds;

1. It also eliminates completely the failure of operators to change to PHCN source immediately after power is restored. This may be due to nonchalant attitude toward his duty or sleeping in the night.
2. Automatic switching reliefs people of many monotonous operators to effect switching at an instance of failure in one source.
3. It minimizes the fuel after PHCN supply is restored.
4. Modern complex switching systems can perform functions which are beyond the physical ability of people to duplicate.

1.3 STATEMENT OF PROBLEM

The problem associated with manual switching systems is that they are susceptible to human errors. The operator could forget to switch ON or OFF when it is required. The only solution is to design and construct the automatic generator start and change over module to automatically control itself.

1.4 SCOPE OF PROJECT

In this work an attempt was made to design and construct an automatic generator start and change over module. The first part of the module is designed to ensure that when there is mains, the generator stop switch is ON and the load connected to the mains. The second portion is designed to switch OFF the generator ON/OFF switch and connect the load back to the mains.

1.5 JUSTIFICATION

The only solution to the problems of manual switching of generator and the changeover is to design an automatic system that will be able to sense the absence of the mains supply, start the generator and engage the generator with the load through the changeover. Furthermore, the system should be able to stop the generator as soon as the mains supply is restored and switch the changeover to the supply, hence the need for this project.

1.6 REPORT OUTLINE

This work is divided into five chapters to make a good report of the project. The first chapter covers the general introduction to the whole project, the objectives as well as problems encountered. Previous works consulted on the topic were highlighted in the second chapter. The theoretical background, analysis of the work, design aspect as well as the implementation of the projects was discussed extensively in the third chapter. The fourth chapter covers the tests carried out, the results obtained as well as the discussion of the results obtained. Finally, conclusions drawn from the project and recommendations were highlighted in the last chapter.

CHSAPTER TWO: LITERATURE REVIEW

2.1 INTRODUCTION

Cummins (2002) highlighted in Modern Control System that electronic intelligence controls some physical process. Control systems are the automations in such things as automation pilot and automation washer. Because the machine itself is making the routine decisions, while the human operator is forced to do other things. In many cases, machine intelligence is better than direct human control because it can react faster or slower more precisely and maintain an accurate lot of the system‟s performances. Early machines were simple machines that substituted one form of effort with a more humanly manageable effort, as lifting a large weight with a system of pulleys or a lever. Later machines were also able to substitute natural forms of renewable energy, such as wind, tides or flowing water for human energy. The sail boat replaced paddled or oared boat. Still later, early forms of machinery were driven by clock type mechanisms or similar devices using some form of artificial power source as wound up spring, channeled flowing water or system to produce some simple repetitive action such as moving figures, making noise or starting a generator. Such early moving devices featuring human like figures were known as automatic and date back to 300BC. Joseph Jackquard (1801) stated that the patent was issued for the automated room using punched cards. Shuaibu (2009) used comparators, D-type flipflop, logic gates, 555 timers and relays to construct an automatic generator start and change over for single phase generators. Musa (1992) used D flip-flops, 3-input AND gates, 555 timers and relays to also construct automatic generator start and change over for single phase generators. This study used readily available components like transformer, JRC 4558 IC, 555 timers and relays in the construction of an automatic generator start and change over module with under voltage and over voltage control.

2.2 FUNCTION

The main function of the automatic generator start and change over module is to provide a steady power supply with the help of some mechanisms that starts the generator set automatically. When there is failure of power supply from PHCN source and it also shuts down the generator set and switch to PHCN source when available.

2.3 COMPONENTS

2.3.1. Transformer:

Theraja (2006) said a transformer is a device that changes the value of electrical voltage/current in one winding to a different value of electrical voltage/current in another winding. That is step up or step down and its schematic symbol is as depicted in Fig.2.1

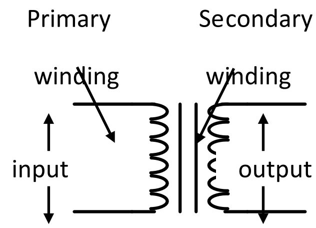

Figure2.1: *Schematic Symbol of a Transformer*

2.3.2 Diode:

A diode is a semiconductor device which allows current to flow through it in only one direction. Diodes are made from germanium or silicon and are commonly referred to as „junction diodes‟ due to the fact that are made so that one half of the material has a predominance of positive charge carriers and the other half has a predominance of negative charge carriers. The circuit symbol of the diode is as shown in Fig. 2.2.

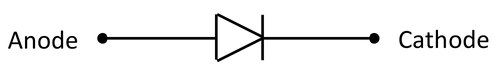

Figure 2.2: *Symbol of a Diode*

2.3.3 Capacitor:

Capacitors are components which specially have two pieces of conducting materials separated by insulating materials called dielectric. The physical realization of this basic arrangement is many and varies. Fig. 2.3 shows the symbols of a capacitor.

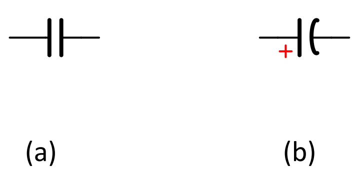

Figure 2.3: *Symbols of capacitor; (a) Non electrolytic. (b) Electrolytic*

2.3.4 Resistor:

A resistor is an electrical component designed specifically to provide obstruct or limit current flow. It is also a circuit component specifically designed to have a known resistance called resistor and the unit is in ohms when current flows through a resistor. If a source of voltage is connected to it, this causes a potential difference to be developed across it. Whether fixed or variable (see Fig. 2.4), they are commonly made of metals and alloys.

(a) **50%** (b)

Figure 2.4: *Resistor Symbols; (a) Fixed. (b) Variable*

2.3.5 JRC 4558 IC

DESCRIPTION

The JRC4558 is a high performance monolithic dual operational amplifier.

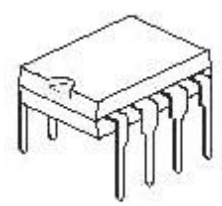

Figure 2.5 *JRC 4558 IC*

FEATURES

No frequency compensation required

No latch – up

Large common mode and differential voltage range

Parameter tracking over temperature range

Gain and phase match between amplifiers

Internally frequency compensated

Low noise input transistors

Pin to pin compatible with MC1458/LM358

PIN CONFIGURATION

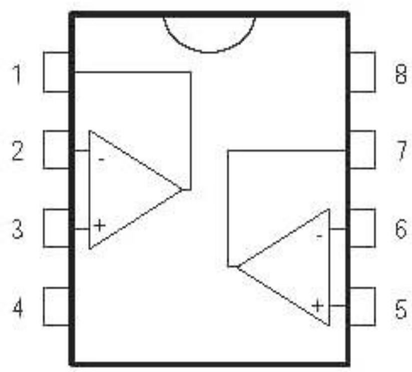

Figure 2.6 *JRC 4558 pin configuration*

1-Output 1

2-Inverting input 1

3-Non-inverting input1

4-Vcc

5-Non-inverting input 2

6-Inverting input 2

7-Output 2

8-Vcc +

MAXIMUM RATINGS

PARAMETER	SYMBOL	VALUE UNIT
Supply Voltage	Vcc	±22 V
Differential Input Voltage	VI(DIFF)	±18 V
Input Voltage	VI	±15 V
Operating Temperature	TOPR	-20~ +85
Power Dissipation	P-DIP 8	400 mW
Storage Temperature Range	TSTG	-65~+150

2.3.6 RELAY

This is an electromagnetic or solid state device operated by variation on the input voltage, which in turn operates or control other devices connected to the output. It is a control to circuits having one or more sets of contacts which operate to open or close contact the contacts whenever the coil is energized. As shown in Fig. 2.7, relay contacts are of two types; normally close (NC) and normally open (NO).

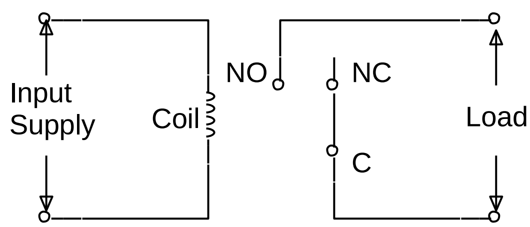

Figure 2.7: *Typical Relay Symbol*

2.3.7 THE 555 TIMER IC:

Wikipedia (2009) stated that the 555 timer IC was first introduced around 1971 by the Signetics Corporation as the SE555/NE555 and was also the very first and only commercial timer IC available. It is after 30 years still very popular and used in many schematics. The 8-pin 555 timer must be one of the most useful ICs ever made and it is used in many projects. With just a few external components it can be used to build many circuits, not all of them involve timing! The circuit symbol for a 555 (see Fig. 2.8) is a box with the pins arranged to suit the circuit diagram. Usually just the pin numbers are used and they are not labeled with their function. The 555 and 556 can be used with a supply voltage (Vs) in the range 4.5 to 15V (18V absolute maximum).

The input and output pin functions are described briefly below;

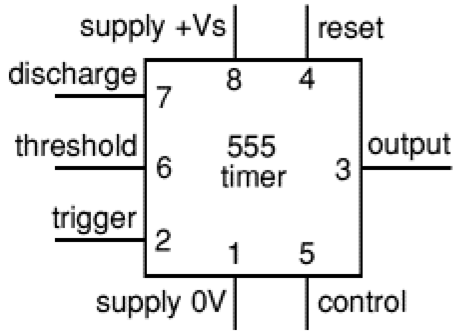

Figure 2.8: *Circuit symbol of the 555 timer*

555 INPUTS:

Trigger Input: When a voltage less than $^1/_3$ Vs ('active low') is applied to this input, it makes the output high (+Vs). It has a high input impedance; > 2MΩ

Threshold Input: When a voltage greater than $^2/_3$ Vs ('active high') is applied to this input, it makes the output low (0V) providing the trigger input is at a voltage less than $^1/_3$ Vs, otherwise the trigger input will override the threshold input and hold the output high (+Vs). It monitors the charging of the timing capacitor in monostable circuits. It has a high input impedance; > 10MΩ.

Reset Input: When at a voltage less than about 0.7V ('active low') this makes the output low (0V), overriding other inputs. When not required it should be connected to +Vs. It has an input impedance of about 10kΩ.

Control Input: This can be used to adjust the threshold voltage which is set internally to be $^2/_3$ Vs. Usually this function is not required and the control input is connected to 0V with a 0.01μF capacitor to eliminate electrical noise. It can be left unconnected if noise is not a problem.

The discharge pin: is not an input, but it is listed here for convenience. It is connected to 0V when the timer output is low and is used to discharge the timing capacitor in monostable circuits.

555 OUTPUT:

The output of a standard 555 can sink and source up to 200mA. This is more than most ICs and it is sufficient to supply many output transducers directly, including

LEDs (with a resistor in series), low current lamps, piezo transducers, loudspeakers (with a capacitor in series), relay coils (with diode protection) and some motors (with diode protection). The output voltage does not quite reach 0V and +Vs, especially if a large current is flowing.

Relay Coils and Other Inductive Loads:

Like all ICs, the 555 must be protected from the brief high voltage 'spike' produced when an inductive load such as a relay coil is switched off. The standard protection diode must be connected 'backwards' across the relay coil. However, the

555 require an extra diode connected in series with the coil to ensure that a small 'glitch' cannot be fed back into the IC. Without this extra diode monostable circuits may re-trigger themselves as the coil is switched off! The coil current passes through the extra diode so it must be a 1N4001 or similar rectifier diode capable of passing the current, a signal diode such as a 1N4148 is usually not suitable.

555 MONOSTABLE

A monostable circuit produces a single output pulse when triggered. It is called a monostable because it is stable in just one state: 'output low'. The 'output high' state is temporary. The duration of the pulse is called the time period (T) and this is determined by resistor R1 and capacitor C1:

Time Period, $T = 1.1 \times R1 \times C1$

Monostable operation:

The timing period is triggered (started) when the trigger input (555 pin 2) is less than $^1/_3$ Vs, this makes the output high (+Vs) and the capacitor C starts to charge through resistor R. Once the time period has started further trigger pulses are ignored. The threshold input (555 pin 6) monitors the voltage across C and when this reaches $^2/_3$ Vs the time period is over and the output becomes low. At the same time discharge (555 pin 7) is connected to 0V, discharging the capacitor ready for the next trigger. The reset input (555 pin 4) overrides all other inputs and the timing may be cancelled at any time by connecting reset to 0V, this instantly makes the output low and discharges the capacitor. If the reset function is not required the reset pin should be connected to +Vs.

Power-on reset or trigger:

It may be useful to ensure that a mono stable circuit is reset or triggered automatically when the power supply is connected or switched on. This is achieved by using a capacitor instead of (or in addition to) a push switch. The capacitor takes a short time to charge, briefly holding the input close to 0V when the circuit is switched on. A switch may be connected in parallel with the capacitor if manual operation is also required. This arrangement is used for the trigger in the Timer Project.

CHAPTER THREE: ANALYSIS, DESIGN AND IMPLEMENTATION

3.1 THEORITICAL BACKGROUND AND ANALYSIS

The automatic generator start and change over module was designed in sections.

These sections are the blocks that make up the block diagram of the module.

3.1.1 BLOCK DIAGRAM

The block diagram is shown in Fig 3.1. It is made up of six blocks namely; the mains supply, sensor, starter, generator, change over and the load. The functions of these blocks are described under.

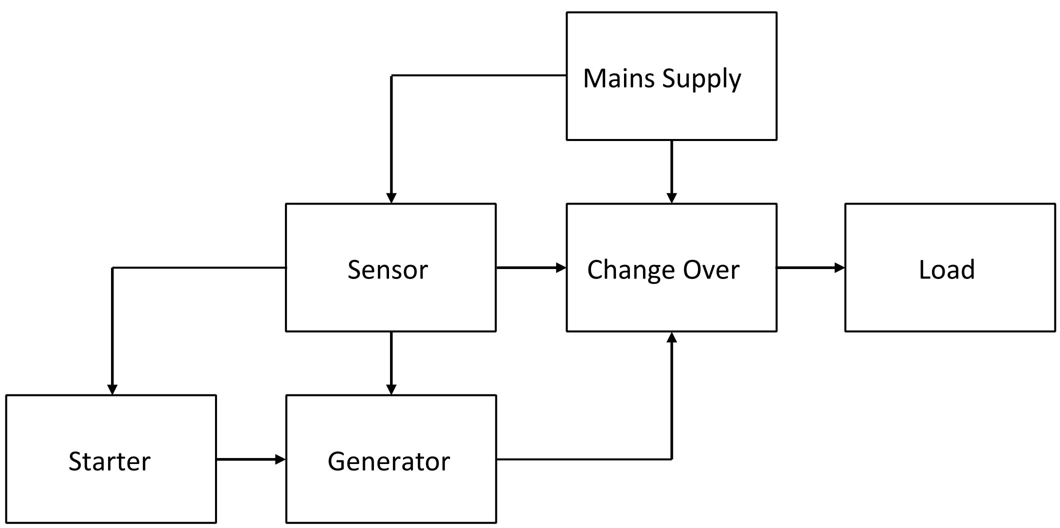

Figure3.1**:** *Block Diagram of the Automatic Generator Start and Change Over*

Module

Mains Supply

The mains supply is a single phase public supply from Power Holding Company of Nigeria (PHCN) PLC. It supplies the sensor through the power supply and the load through the changeover.

Sensor

The sensor is consists of an unregulated dc power supply unit, an over voltage and under voltage control unit and a 12volts relay which acts as the main sensor. The regulated voltage reaches the relay which is in a normally closed state and opens it. In this state, the load is fed by the mains supply and generator is off. In the absence of the main supply, the relay move to its normally closed state, allowing the 12volts battery supply to power the starter thus starting the generator.

□□□□□□□□

On receiving a failure signal from the sensor, the starter sends a starting current sufficient to starts the generator. This is done by the 555 timer IC connected in the monostable or one shot mode that is programmed to drive a relay that supplies the starting current to the generator for a period of time just enough to start the generator.

Generator

The generator is the standby or alternative power source used whenever the mains supply fails. It gets its starting and stopping signals from the starter and the sensor respectively and supplies the load through the changeover module.

Change Over

The generator is connected to the load after a predetermined delay period whenever mains supply fails. When mains supply is restored the load is immediately connected back to mains supply. These actions are performed by the change over which consists of a 555 timer IC one shot driving a six terminal relay or contactor.

Load

This is the equipment, or device that consumes the power being supplied by the two sources. The load is connected to only one of the source at any one time by the changeover.

3.2 DESIGN

This work is only concerned with the design and construction of an automatic generator start and change over module with under voltage and over voltage therefore, only components in the sensor, starter and change over units are determined. The two sources, PHCN mains and generator, and the load are expected to be in existence prior to the design. It is very essential that the generator is key started.

3.2.1 SENSOR

The sensor is made up of the power supply (a step down transformer and four diodes), the over voltage and under voltage control (IC JRC4558 and resistors) and the

12volts relay.

Power Supply

A 240/ (12x2) step down transformer was chosen and diodes D1, D2, D3 and D4 are chosen to be 1N4001 for general purpose. The transformer resultant output voltage is

given by; $V_{peak} = \sqrt{2}\ X\ V_{max} = \sqrt{2}\ X\ 12 = 16.97V$

a full wave bridge rectifier was chosen using IN4001 diode. The DC voltage is given by;

$$V_{dc} = \left(\frac{2}{\pi}\right) X\ V_{peak}$$

$$V_{dc} = \left(\frac{2}{\pi}\right)\ X\ 16.97$$

$$V_{dc} = 10.8V$$

Filter Section

It is preferable to choose a filtering capacitor that will hold the peak-to-peak ripples at approximately 8% of the peak voltage. Therefore using the values obtained from above, the value of the filter capacitor is calculated as shown below

$I_{\min}$ □ I_{dc} □ $500mA$

V_{rms} □ $2\sqrt{□}V_m$

V_m □ $12v$

V_{rms} □ $16.9v$

RF □ $8\ 00$

$V = \frac{8}{...} = 16.9 = 1.35 v_r$ 100

$C = \frac{I_{dc}}{4 f V_r} = 1851.85 f$

Therefore a standard value of 2200uf was chosen based on the value obtained.

Switching Section

This is done by the transistor BC107

$VcBo = 50V$

VcEo = 45V Ic max =

200mA hFE = 450

$$Ic = \frac{VCC - VCE}{Rc} = \frac{12-5}{1000} = 0.7mA$$

$$Ib = \frac{Ic}{\beta} = \frac{0.7}{200} = 0.0035mA$$

Voltage Regulation

As a result of the 12V requirement of the circuit components used, it is paramount to use a 12V

Voltage regulator. LM 7812 was chosen because it can provide up to 1A load.

The relays RLY1 and RLY2 were chosen to be 12V/180Ω. Therefore the relay current

is given by;

$$I = \frac{V}{R} = \frac{12}{180} = 67mA$$

Under voltage and over voltage control

A dual operational amplifier JRC4558 was used as a comparator, to compare the referenced voltage with the other two input voltage.

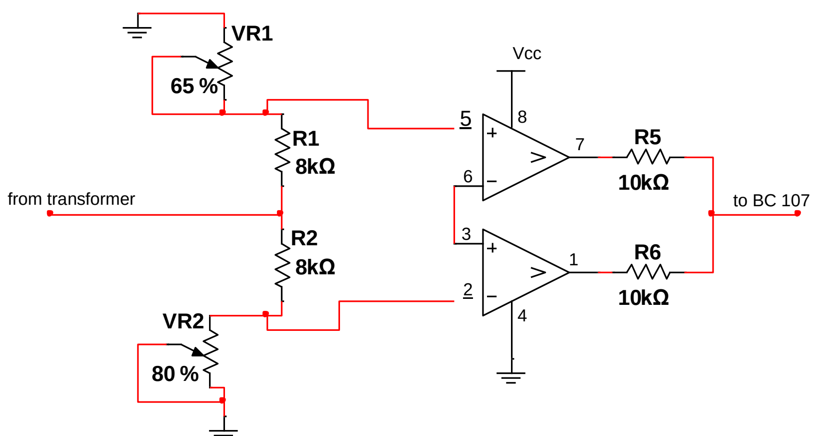

Figure 3.2 *under voltage and over voltage control circuit*

The reference voltage of pin 3 and 6 = 5volts

Transformer ratio = 10:1

Resistors R1 & R2 are chosen to be 8kΩ each.

Under voltage

The under voltage set point was chosen to be 170volts at primary site of the transformer. Therefore equivalent voltage at the secondary is given by

$$Vs = \frac{Vp}{K1} = \frac{170}{10} = 17\text{V}$$

Voltage across R2 is given by; $R2\frac{Vs}{R1+R2} - - - - - - - - -VDR$

$$= \frac{8\ X\ 17}{8+8} = 8.5\text{V}$$

Choosing 4.3Volts at pin 2 at the set point voltage (170V)

The value of VR2 is obtain using VDR

$$\frac{VR2X8.5}{VR1+8} = 4.3V$$

$$VR2 = \frac{8\ X\ 4.3}{8.5-4.3} = 8.2\text{k}\Omega$$

<u>Over voltage</u>

Over voltage set point is chosen to be 245Volts

Equivalent voltage at the secondary site of the transformer

$$\frac{Vs}{K1} = \frac{245}{10} = 24.5\text{V}$$

Voltage across R1

$$\frac{\text{R1 X 24.5}}{\text{R1+R2}} = 12.25V$$ - - - - VDR

Choosing 5.7volts at pin 5 at set point, the value of the variable resistor is given by;

$$VR1\frac{12.25}{VR1+R1} = 5.7$$ - - VDR

$$VR1 = 8\frac{5.7}{12.5-5.7} = 6.7K\Omega$$

In view of the values of VR1 and VR2 obtained from the calculations above, the variable resistors were chosen to be 103 each which equivalent to 10kΩ.
They are set at 8.2kΩ and 6.7kΩ for the under voltage and over voltage respectively.

3.2.2 STARTER

The starter is a 555 timer connected as a mono stable triggered ON when mains

(PHCN) fails. To start the generator, the 555 is connected as shown in fig. 3.3 below. Here the pulse out has a duration of t = 1.1 x R x C5

Therefore, for a 1 second starting pulse, t = 1s, and taking C5 = 1µF, then

$$R = \frac{t}{1.1 \times C5} = \frac{1}{1.1 \times 1 \times 10^{-6}} \approx 1M\Omega$$

This value is divided into two (2) in the real circuit so that the starting time can be varied to start the generator. Hence VR1 = 500KΩ and R2 = 500KΩ.

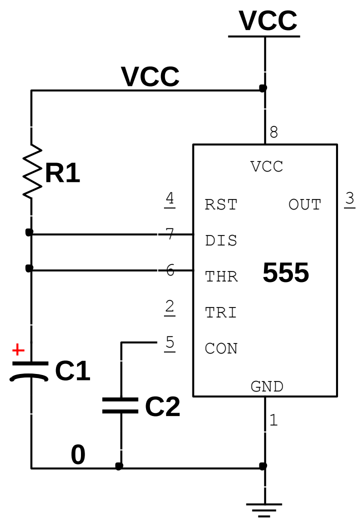

Figure 3.3: *The generator start circuit*

3.2.3 CHANGE OVER

The changeover is also a 555 timer connected as a mono stable triggered ON when mains fail and to switch load from PHCN to generator after about a 2 seconds

tolerance for the generator starting current to off. Let t = 2 seconds, and selecting C7 = 2µF, then

$$R = \frac{t}{1.1 \times C7} = \frac{2}{1.1 \times 2 \times 10^{-6}} = 0.91M\Omega$$

This value is also divided into two (2) in the main circuit so that the change over time can be precise. Hence standard resistors of R14 = R15 = 470KΩ were chosen.

3.2.4 TRIGGER INPUTS (PIN 2)

The 555 must be triggered by applying a voltage less than $^1/_3$ Vs to pin 2 and the voltage at pin 2 is always within this range at start up. Therefore for both the starter and the changeover not to retrigger, appropriate timing components must be determined to raise the voltage at pin 2 to a value greater than $^1/_3$ Vs before their timing periods run out. Let trigger input pulse be much less than any of the mono stable periods of 1 second and 2seconds.

t << 1s

Choosing t = 0.1ms and R = 100kΩ

$$\therefore C = \frac{t}{R} = \frac{0.1 \times 10^{-3}}{100 \times 10^{3}} = 1 \times 10^{-9} = 1nF$$

Hence, R10 = R13 = 100kΩ while C3 = C6 = 1nF

Pins 5 of the 555 timers are grounded via 10nF capacitors as recommended by the manufacturer to filter trigger signals.

3.2.5 RELAY PROTECTING DIODES

The relay coils used in this work need to be protected from reverse bias and this is done by connecting a reverse biased diode connected across each of the coils. This diode must have a high peak inverse voltage (PIV) rating.

Hence D5 = D6 = D7 = 1N1004 with PIV > 100V.

3.2.6 PARTS LIST

The part list of the automatic generator start and change over module are as follows:

S/N	Component	Label	Value	Quantity

1.	Transformer	T1	12x2 V	01
2.	Diode	D1 – D7	1N1004	07
3.	Capacitor	C1	2200 µF	01
4.	Capacitor	C3 & C6	1 nF	02
5.	Capacitor	C4	1µF	01
6.	Capacitor	C5 & C8	10 nF	02
7.	Capacitor	C7	2 µF	01
8.	Battery	V1	12 V	01
9.	Relay	RLY1 – RLY2	12V/1P	02
10.	Relay	RLY3	12 V/6T	01
11.	Resistor	R1& R2	15kΩ	02
12.	Resistor	R5 & R6	10 kΩ	02
13.	Resistor	R8, R10 &13	100k	03
14.	Resistor	R11,R12,R14&R15	470k	04
15.	Resistor	R9	4.7k	01
16.	Variable Resistor	VR1 & VR2	500kΩ	02
17.	Integrated Circuit	U1 & U2	LM555CN	02

Table1. parts list

3.3 IMPLEMENTATION

CONSTRUCTION

Construction needs a little skill to achieve a correct and neat job. It is a process of connecting all the components together using the necessary steps and equipment to construct a functional unit. The circuit diagram was first analyzed and the components that make up the circuit were made ready. The Vero board was then cut to size and the components were laid with respect to their polarities as shown in Fig. 3.4.

SOLDERING

It is an act of joining two conductors or components. All the components were wired on the Vero board and considering their polarities. Hence, care was taken when soldering all the active components so as to avoid damage by excessive heat. In soldering the components, a soldering iron having a low power rating of 40W at 25C was used to avoid dry joint and short circuiting.

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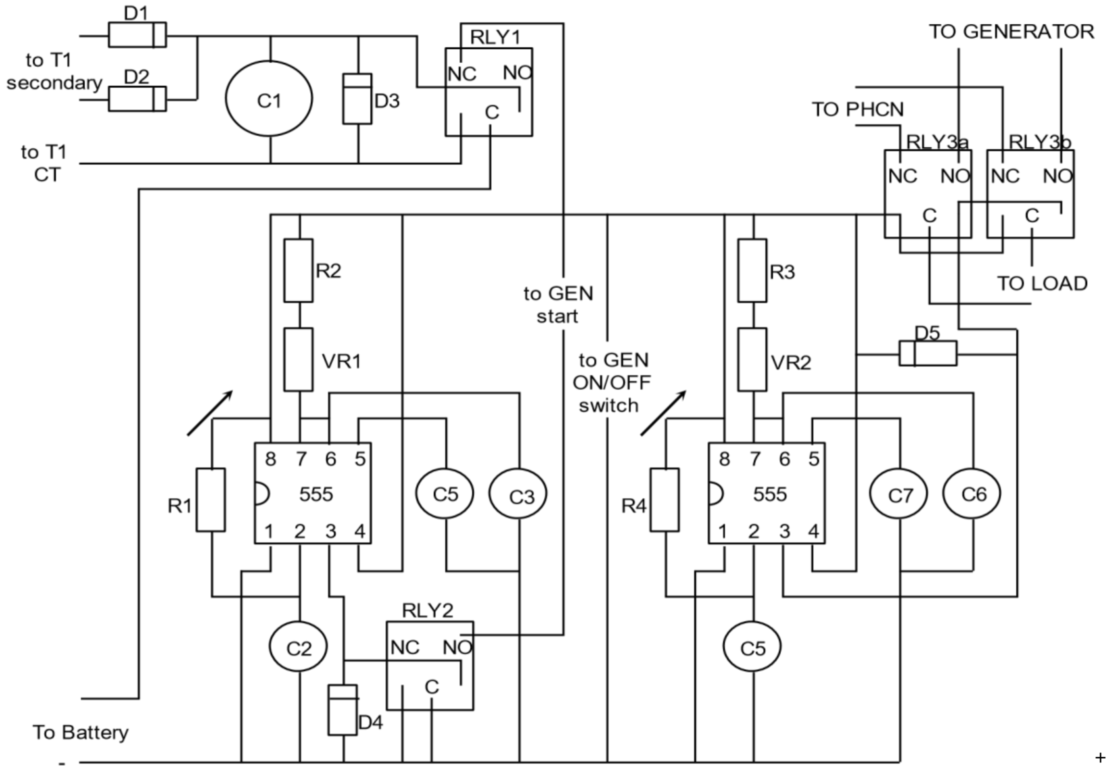

Figure 3.4: *Component Layout of Automatic Generator Start and Change Over Module*

CASING

A portable and handy wooden box of was constructed for casing the entire system. Wood was chosen because it is cheap and also because it is an insulator. The casing was carefully perforated at the back for adequate ventilation. The sVero board on which all the components were laid was fastened to the base of the casing internally with small bolts and nuts. The transformer was also fastened to the base of the casing in order to avoid shaking and damage of the circuit.

CHAPTER FOUR: TESTS, RESULTS AND DISCUSSION

4.1 TESTS

The complete construction was tested by connecting it and powering it. The connections were made to the appropriate points of the generator. When mains was switched OFF, the module started the generator, isolated the load and after a while connected the load to the generator.

4.2 RESULTS

The results gotten from testing the automatic generator start and change over module are as follows

S/N	TEST	DURATION
1.	Starting time	1.8 seconds
2.	Change over time	2.2 seconds
3.	Triggering time	0.2 seconds

Table of results

4.3 DISCUSSION

The constructed circuit was tested and found to conform to the design considerations except for the slight differences in the timing of not more than 0.5 seconds in the starting time and about 0.2 seconds in the changeover. This is due to the tolerance value of both resistors and capacitors used.

CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 SUMMARY

The design and construction of the automatic generator and change over module with under voltage and over voltage control was carried out in a sequential order starting from the design analysis, simulation of circuit diagram, bread boarding, implementation and tests. The main purpose of the project is to eliminate the manual switching method used in starting and stopping generators at our various houses, offices, industries e.t.c.

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The exercise of designing the module is of great significance due to the erratic nature of our mains power supply and our dependency on data centres and network rooms for computer and telephone services. It is laudable to note that all goals are achievable within available resources and constraints. The exercise proved that simple equipment and systems could be conceived, designed and fabricated locally, thereby reducing the effect of importation from foreign countries.

5.3 RECOMMENDATIONS

The main limitation of this work is that the issue of voltage fluctuation which will leads to intermittent starting and stopping of the generator could not be addressed, as such I hereby recommend for further research be carry out to solve this problem by anybody intending to work on similar project. The department should also try as much as possible to introduce a course based on design and construction of electrical circuits as this will help immensely in preparing students for both mini and final year projects. It will also minimize unnecessary consultations made by students during projects since they have acquired the basic knowledge. Finally laboratories in the department should be equipped with sufficient practical apparatus and not just modern ones as this will give room for every student to participate actively in all practical works.

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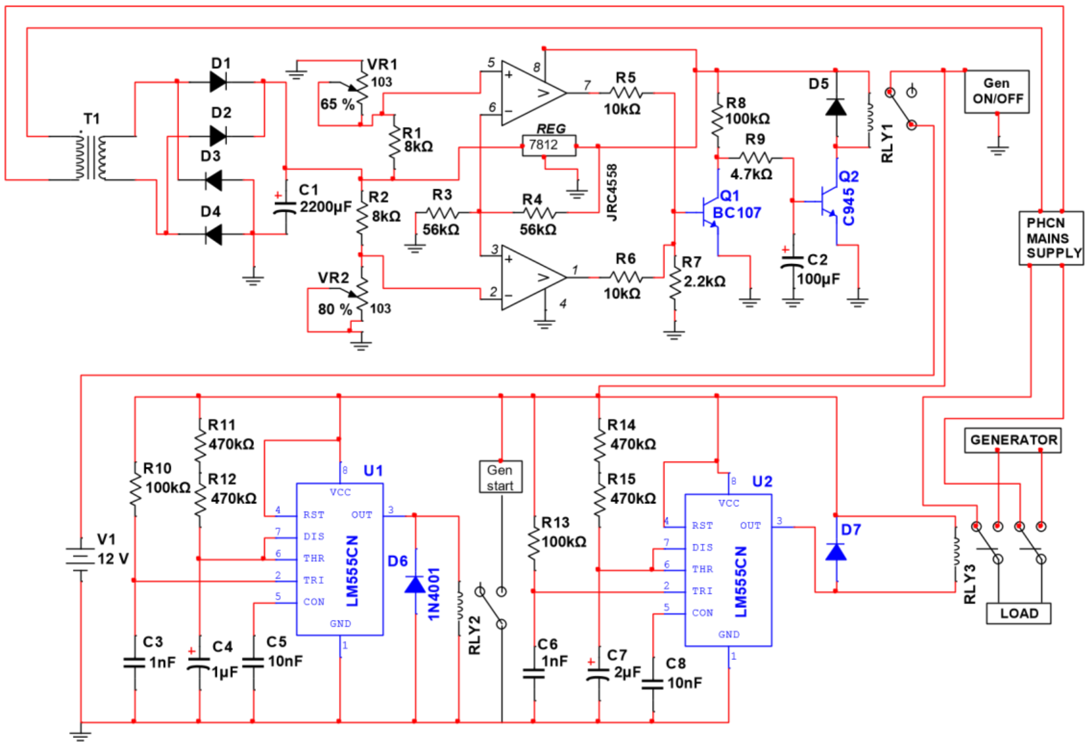
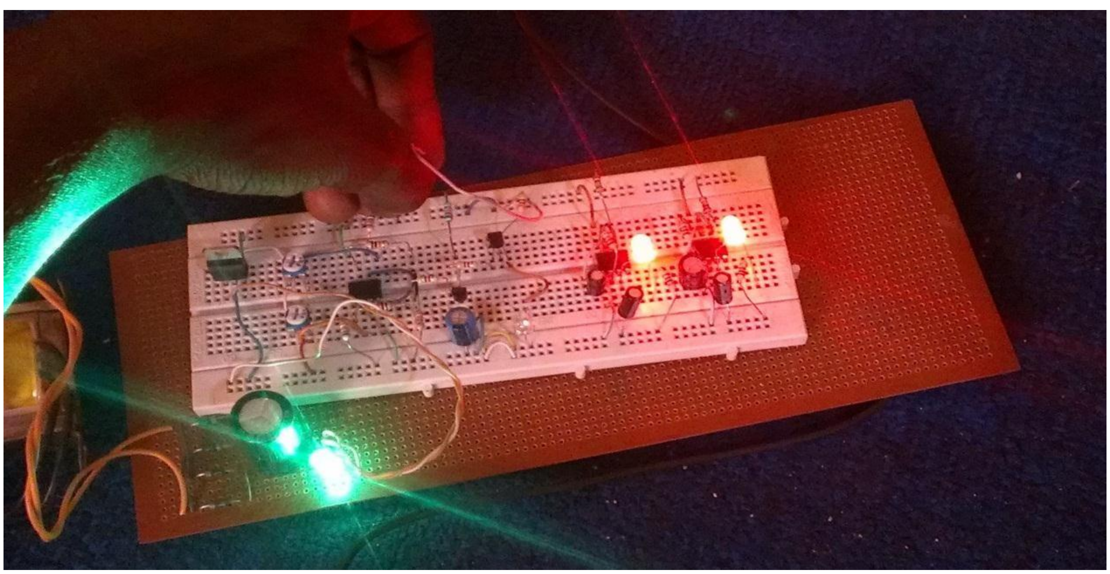
APPENDICES

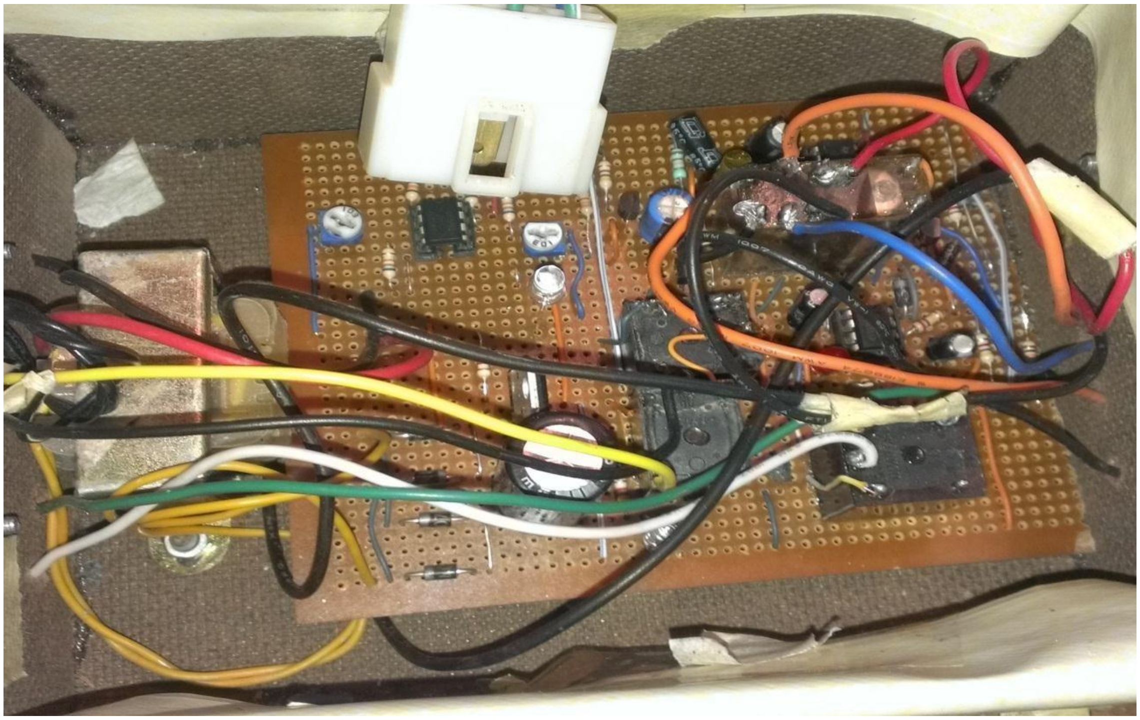
APPENDICE A



Circuit Diagram of the Automatic Generator Start and Change Over Module APPENDICE B

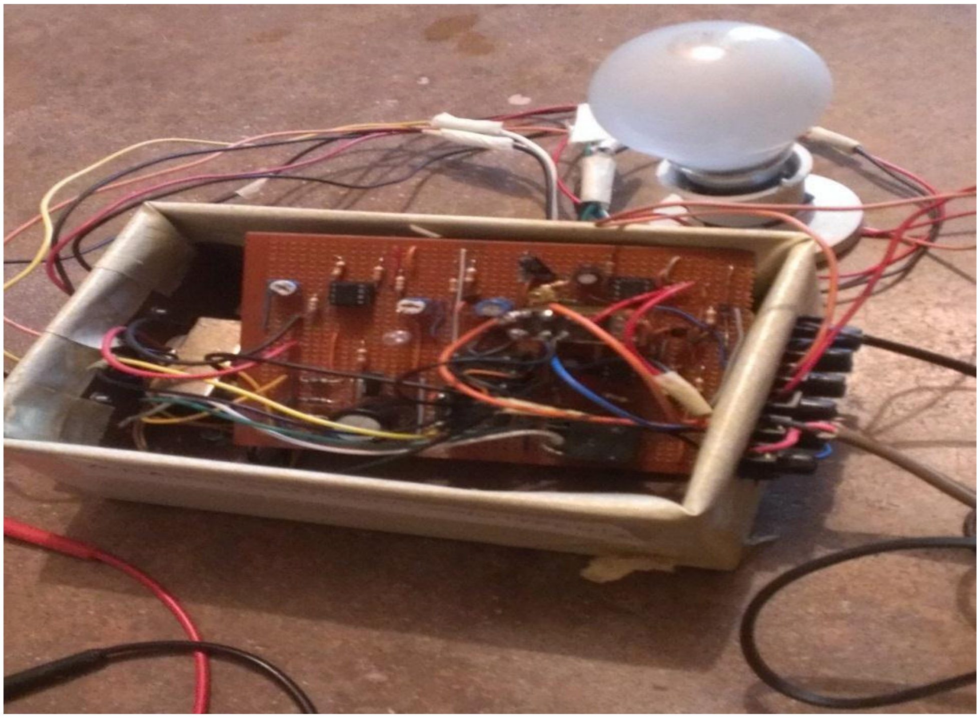


Picture of the bread boarding under test



Picture of soldered project on Vero board

APPENDICE C



Pictures of complete constructed project.

Picture of constructed project with casing