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An Enhanced 60 Amps Single-Phase Automatic Power Change-Over Switch System

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ABSTRACT : *There is an increasing demand by the populace living in residential areas, offices and industrial locations in Nigeria, where public power supply from the eleven electricity power distribution companies (DISCOs) have become erratic and unpredictable. Due to the rampant and frequent fluctuation of public power supply in Nigeria, changing from public power supply to alternative sources of power such as generating set has become cumbersome, time-demanding and expensive. Power consumers in residential homes, offices and industrial layouts therefore have a need for an effective and efficient automatic change-over power switching to maintain power continuity so as to remove any interruption or delay. In this paper, an efficient and effective automatic power change-over switch system was designed and implemented to help switch over to public power supply mode, when there is availability of power and then return to an alternative power supply such as generator mode, when public power supply goes off, automatically without human intervention. The system was tested with a public power supply and a generating set and it yielded the desired results*

KEYWORDS: *Switch, Automatic change-over switch, Manual Change-over, generator mode, public power supply , Relay, Transformer, DISCOs, Nigeria*

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I. INTRODUCTION

There is an intense demand by the populace in residential homes, offices, business premises and industries in Nigeria for change of power supply switch for effectiveness and continuity of power supply, without a notice interrupt or delay, when public power supply goes off from the DISCOs (Distribution Power Companies e.g. EEDC), or returns back. Before now, switching over from a public power supply to a generator and back has always been performed manually via human intervention through the use of a manual change-over switch. The manual change-over switch was better than nothing at all but its performance was not satisfactory and efficient.

The automatic change-over switch can be described as a unique switching system which can be used to change power from one power source to another. The equipment will switch between two different electrical sources: usually from a public power supply to a generator and vice versa. The relaying and triggering system serve as interface between the public supply, the generator and the load. When there is a power failure from public supply, the relaying unit senses the power outage and thus changes over to the stand-by power source (e.g. a generator).

However, the automatic change-over is a device that links the load and the main supply or the alternative supply together. Change over switch from immemorial has been manually controlled. This has been a good means of power change over. When there is unexpected power outage from the public supply, it takes the user or operator some time and strength to get to the change-over power point to interchange the switch. This process was discovered to be time wasting and often result to loss of resources, sometimes a dedicated laborer or operator is employed to handle this job, which must be paid his wages or salaries.

Another demerits of manual power change-over is an instance in a hospital when surgical operation is going on and power unexpectedly goes off , before the power will be restored using mechanical or manually operate change-over switch, the surgery may lead to failure and the patient may die. Another example, in an airport where should be steady supply of power and in business sectors, losses are bound to occur if power is not quickly restored when there is power outage.

Nowadays the rate at which more efficient electrical and electronic gadgets are being procured and installed are on the increase, there is equally need for a faster and more reliable change-over system in an invent of power outage. Also machine damage sometimes occurs because of human error. This can lead to significant financial losses. This change-over switch uses an electronic control circuit involving relays, diodes, ICs, microcontrollers, resistors, transformer, capacitors, etc. A manual change over switch consists of a manual change over box, switch gear, and cut out fuse or the connector; this change over switch box separates the source between public and generator supply, when there is power supply failure from the public supply, someone has to go change line to generator. Also, when power is restored, someone will go and put off the generator and change the switch back to the public power supply. In view of the above manual change over switching system that involves manual power by someone starting the generator and vice versa when the supply is restored. Thus, this automatic change over is designed to help solve the problem of human strength and the danger likely to occur.

II. RELATED WORKS

Lots of works have been carried out in literature on automatic change-over power switch systems.

Author in [1] proposed and implemented an automatic power change-over switch using integrated circuit (IC) with timing abilities and relays to effect switching functions. The system ensures automatic power change-over to a generating set once the public utility or power supply goes off.

Authors in [2] proposed, designed and implemented an automatic change-over switch (with step loading) for renewable energy systems. The system utilized microcontroller to handle the control for the automatic change-over function. It consists of power supply circuit consisting of step-down transformer, rectifier (full wave bridge); filter capacitor and the voltage regulator, logic circuit that detects when utility supply is restored, an astable multivibrator integrated circuit (555timer) which triggers the audio and visual indicators respectively. It made use of renewable energy sources such as the sun (solar) to generate backup energy for the device via inverter.

Author in [3] proposed and implemented an automatic phase change-over switch to disconnect load from its power source and transfer it to a standby source say generator, in case there is a power outage. The switching process is done in a controlled manner so as to prevent the false starting of generator at very short power outages. Immediately the supply is restored, the load is transferred back to mains supply The entire process is controlled by a control unit that keeps sensing to detect that whether the main supply is available or not. The control unit consists of an IC 4060 (a 14 stage frequency divider) that provides all the time delays required in the circuit. The switching function was done using four relays of 12V rating each. It also consists of two transistors BC547.

The authors in [4] designed and implemented a three-phase automatic change over switch with generator control mechanism to provide an automatic switching mechanism that transfers the consumer loads to a power source from a generator in the case of power failure in the mains supply. It automatically detects when power has been restored to the mains supply and returns the loads to this source while turning off the power from the generator set.

III. METHODOLOGY AND MATERIALS

The methods and materials used to design and develop the proposed 60AMPs Automatic Change-Over power switch are presented in this section.

In the construct of this project and as shown in Fig.1, the transformer provides the power used in the circuit and also stabilizes the power to avoid fluctuation.

The rectifier converts the ac power from the transformer to dc power. The capacitor c1 (100µF/25V) is connected to the output of the rectifier which helps in filtering of the ripples from the dc current. It also stores energy (electrical energy) which sustains the circuit at power failure.

The resistor R1 (100Ω) is connected in parallel to c1 and in series with the LED (light emitting diode) which serves as an indicator to the circuit for main supply. R1 resistors the flow of current to the LED from the power supply of the transformer. The voltage regulator is connected to the output of the transformer after rectification and filtration and this regulate the voltage into the control circuit to 12V dc, which then powers the diode.

D1 is connected in parallel to the relay (RL1) and it allows the flow of current in one direction enabling RL1 to trigger when power comes from the main supply .R2 (10 Ω) is connected in series to D1 and this is helps to reduce the amount of current that is to flow into the ground. The normal close of the relay is generator positive terminal while the normal open is the main negative terminal.

It only triggers when the circuit is powered, the common moves to normally open thereby closing the circuit to the main supply negative terminal. D2 is connected parallel to RL2. It allows the flow of current in one direction thereby enabling the RL2 to trigger from generator negative terminal (normal close) to the mains supply positive when the main is NO. The resistor (10 Ω) is connected in series to D2 to resist the flow of current to the ground.

D3 is connected in parallel to RL3. It allows the flow of current in one direction to RL3 thereby enabling it to trigger the ON and OFF switch of the generator. The relay servers as control mechanism of the generator switch, R4 (10 Ω) connected to D3 to resistors the flow of current to the ground. The resistor R5 (100 Ω) is connected to the terminals of the generator supply. R5 is connected in series with the LED which indicates when the generator is supplying power. The resistor R5 reduces the flow of current to the LED

3.1 Circuit Analysis and Construction

The automatic change over switch operates on relay triggering there by selecting power between the mains supply and the alternative supply (generator).

The block diagram of the proposed system is depicted in Fig.2. Here the power unit powers the circuit, thus it provides and regulates the required voltage needed to power the circuit thereby making the components to function very well. The power unit also converts AC to DC voltage which is the used in the circuit. On the other hand, the switching unit is the control circuit and it is actually the heart beat of the system. It controls the switching and triggering of the relays. The main component here is the relay which triggers and switches between the two power source (the mains and the alternative power supplies).

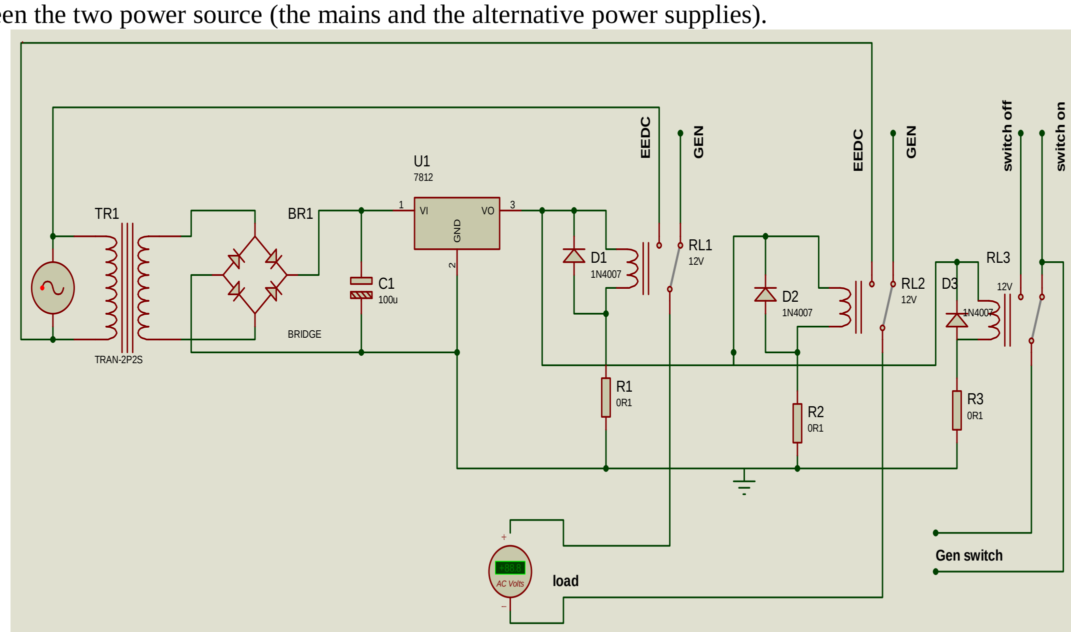

Fig. 1. Circuit diagram of the proposed system using Proteus Simulation 8.0

Fig. 2. The block diagram of the proposed system

Fig.3 depicts the flowchart algorithm for the operation of the switching system.

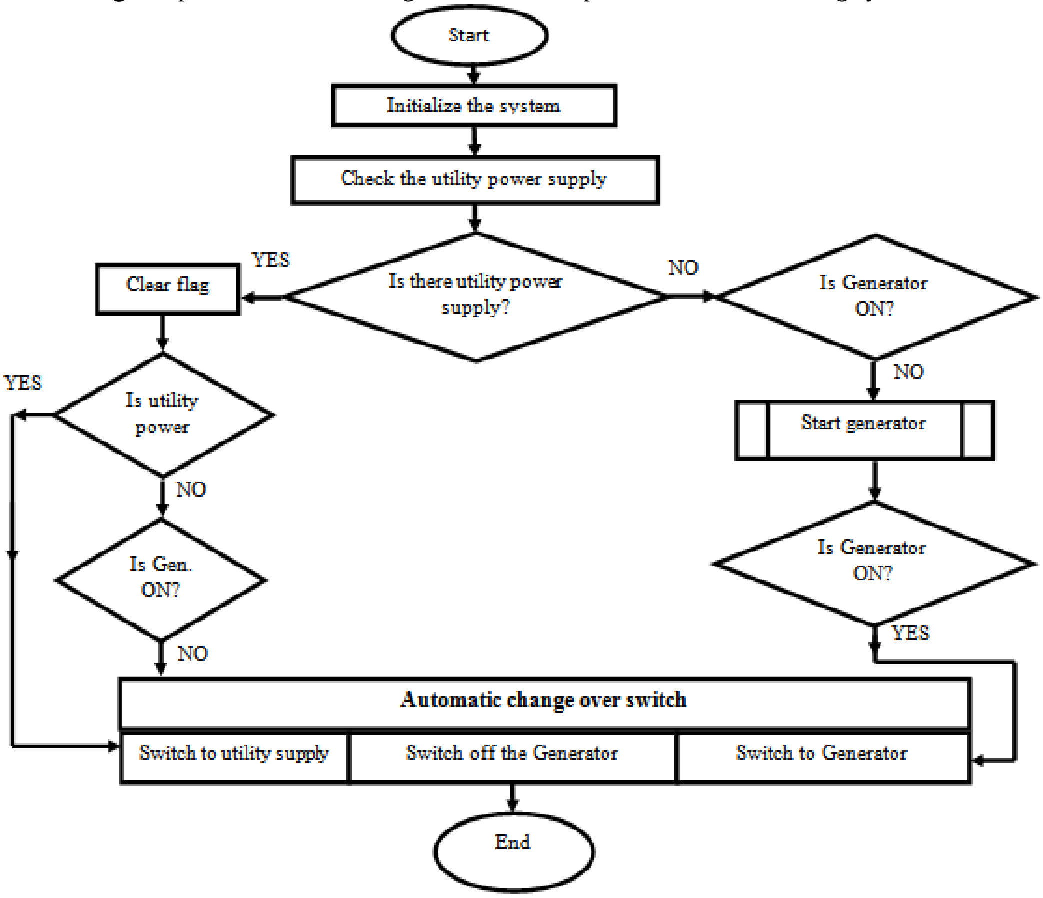

Fig. 3. System flowchart for the operation of the automatic change-over switch

3.2 Operation of the Power Supply

This powers the circuit, thus it provides and regulates the required voltage needed to power the circuit thereby making the components to function very well. The power unit converts AC to DC voltage which is the used in the circuit.

3.3 Operation of the Switching System

The control circuit is actually the heart beat of the system. It controls the switching and triggering of the relays. The main component here is the relay which triggers and switches between the two power source (the mains and the alternative power supplies).

3.4 Components Description

The control circuit is actually the heart beat of the system. It controls the switching and triggering of the relays. The main component here is the relay which triggers and switches between the two power source (the mains and the alternative power supplies).

Transformer:

Generally, transformer is an electrical device that either step up or down input voltage of low or high respectively. In this circuit, we used a step down transformer to reduce the 220-240 Volts to 12 Volts to avoid damage of the rectification device. The circuit symbol of transformer is shown in Fig.4.

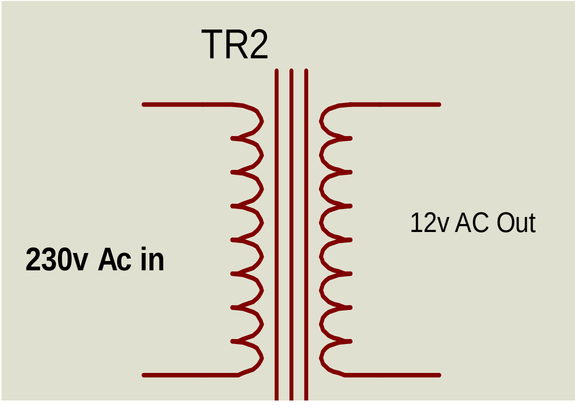

Fig. 4. Circuit Symbol of a Transformer

Rectifier:

The circuit is a dc circuit and cannot make use of the ac voltage supplied by the transformer. However, a rectifier that will convert the ac voltage to DC is to be connected to the output of the transformer. There, a rectifier is an electrical electronic device that converts ac to dc. The rectifier the rectifier can also be constructed by connecting four (4) diodes in the way that they allow current to flow only in one direction. The circuit symbol of bridge rectifier is shown in Fig.5.

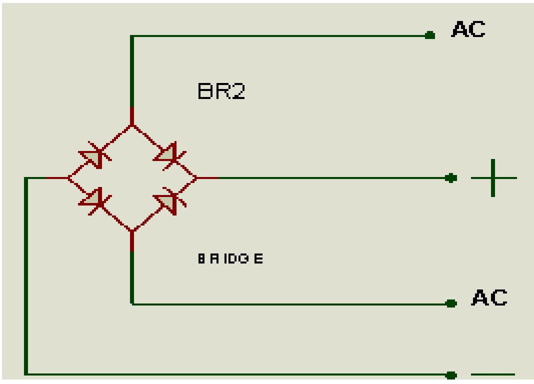

Fig 5: Circuit Symbol of Bridge Rectifier

Capacitor:

Capacitors are used in for different and various purposes in an electronic circuit to achieve a required and desired need. In this project work, the capacitors are used in filtering ripples from the circuit and also for the storage of electrical energy to power the circuit in case of power failure. Fig.6 depicts the circuit symbol of capacitor.

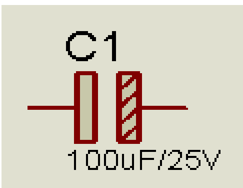

Fig. 6.Circuit Symbol of Capacitor

Resistors:

Resistors are two terminal devices which are designed to oppose the flow of current through it. By doing this it reduces the higher current flow that is capable of destroying a component to normal. They are used in this circuit for current limiting purposes. The circuit symbol of resistor is shown in Fig.7.

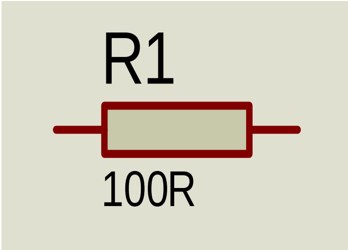

Fig. 7. Circuit Symbol of Resistor

Diode:

This is a two terminals electronic component with a symmetric conductance. It has low (ideally zero) resistance to current flow in one direction and high (ideally infinite) resistance in other direction. The most common function of a diode is to allow electric current to pass in one direction while blocking current in opposite direction. This unidirectional behavior is called rectification and is used in converting alternating current (AC) to direct current (DC) and half wave form. Fig.8 shows the circuit symbol of diode.

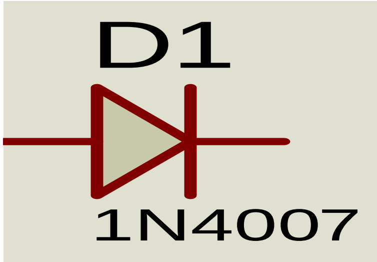

Fig. 8. Circuit Symbol of Diode

Voltage Regulator:

This is an electronic component that is used to a fixed output. in the current, the voltage regulator reduces the output of the transformer to +12 V which is the actual voltage that powers the control circuit. It is a transistor IC with three (3) terminals; (the input, output and the ground. Fig.9 shows the circuit symbol of voltage regulator.

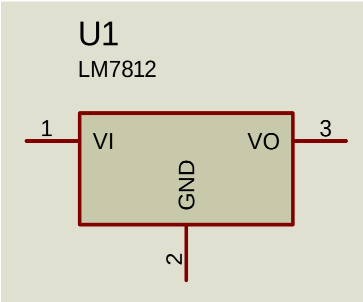

Fig. 9. Circuit Symbol of Voltage Regulator

Relay:

A relay is an electrically operated switch that uses electromagnetic to mechanically operate a switch, but other operating principles are also used such as solid state relays. Fig.10 shows the circuit symbol of relay.

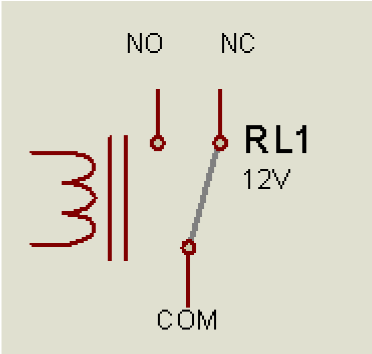

Fig. 10. Circuit Symbol of Relay

3.5 Components Selection

This design is intended to power a load of 12KVA.
Using the formula:
$P = 3I_P V_P \cos\theta$
Where P = the apparent power=12KVA
I_P = The phase current = ?
V_P = the phase voltage = 240v
Cos Θ = the power factor = 0.8
But the active P = apparent power × power factor= $12 \times 10^{3} \times 0.8$ = 9.6 KW
Active P = 3 $I_P V_P$
9600 = 3 × I_P × 240
I_P = 9600 = 9600/3×240
I_P = 13.333 Amps.
The relay required will have a minimum of 13.333 Amps for increase efficiency a tolerance of about +12% will be given.
Therefore the relay rating will be
$13.333 + \frac{(25X13.333)}{100}$=16.666 Amps.
In this design the used is; DC rating 30Amps, 12V AC rating 30Amps/240VIp = 13.333A deduced is current per phase. Thus any cable used should be capable of carrying about $1^{1/2}$ time the current.
The operating environment will also play a role. Required cable should carry a current of at least 13.333 + (50% X 13.333) = 19.999 Amps. Therefore the size of cable recommended is 4mm^2.

3.6 Working Principle

In the project, relays are used as change over unit and the unit is consisted of 3 RLA and a Transformer T, and bridge rectifier.

3.7 Procedure

The transformer steps 220V AC to 12V AC and the bridge rectifier converts the ac to dc and a smoothing capacitor is used to smoothen the dc voltage which is used to power the RLA.
The relay switches the common to mains when transformer is reviving power from source and returns when transformer is cut out of mains couching the common to return to generator.

Indicator:

The indicator shows the presence of the mains. The converted dc is fed to 555 timers with a regular timing and the configuration is shown in the circuit, which helps the user to know when power has come to the mains and this timer is connected to a buzzer.

3.8 Packaging and Labeling Details

The packaging of the finished and completed products is as follow:-
Name: single phase automatic power change over.
Rating: 60Amps – 220/250V – 50Hz

IV. RESULT AND DISCUSSIONS

This section presents the results and discussions on the proposed automatic change-over power switch system.

4.0.1 Results

From the various tests carried out, the following observations were made.

1. The system switched over to public power supply mode when power is available.
2. The system switched over to generator mode, and switched ON the generator, when public supply failed.
3. When the public power supply returned, the system left the generator mode and switched over to the public power source mode, and switched OFF the generator.
4. The system did not attempt to start the generator, when public supply is available.

4.0.2 Discussions

An automatic power change over switch has been designed and constructed. The prototype of the system (automatic power change over) worked according to the specification and quite satisfactorily. The device is reliable and easy to operate. Whenever there is mains (power power supply) power failure, it reduces stress for manual change over which involves manpower. Fig.11 shows the snapshot of the developed automatic change-over power switch system.

Fig. 11. Snapshot of the developed 60Amps Automatic Change-over Power Switch System

The control circuit of the automatic change over switch was tested by connecting wires to both the mains and generator terminals. We observed that the system changed over to generator mode when public source failed and the generator switched ON. We also observed that the system changed to the public source when it was restored and generator switched OFF. Finally, we came to the final observation that the system was designed in a way that it changes from public power source when it fails to private source (generator) mode without interrupt or delay (switching at zero interval) vice versa. This system is simple in design and less complex in hardware. It can easily be produced on a large scale to satisfy a large market like Nigeria where public power supply is highly erratic and unreliable.

V. CONCLUSION

This paper presents a laboratory work on the development of an enhanced easy-to-use, efficient automatic change-over power switch which can be deployed to switch from one power source to another without human intervention. The prototype of the system (automatic power change-over switch) worked according to the specification and quite satisfactorily. The device is reliable and easy to operate. Whenever there is mains power failure, it reduces stress for manual change over which involves manpower. This system is affordable and can be replicated on a mass scale to solve the power problems in Nigeria.

REFERENCES

[1]. Jonathan Gana Kolo : Design and Construction of an Automatic Power Change-over Switch , A Technical Report: AU J.T. 11(2): (Oct. 2007), pp.1-6.
[2]. Osaretin C.A.; Ibhadode E.I. and Igbinovia S.O. : Design and Implementation of Automatic Change-over Switch (With Step Loading) For Renewable Energy Systems. International Journal Renewable Energy and Environment Vol.2, 2016, pp.179-192.
[3]. Uneet Kumar Singh: Automatic Phase Change-over Switch. International Journal of Engineering Trends and Technology (IJETT) – Volume 34, Number 2, April 2016. Pp. 76-80.
[4]. L.S. Ezema, B.U. Peter, O.O. Harris, "Design of Automatic Change over Switch with Generator Control Mechanism", Part-I: Natural and Applied Sciences, Volume 3, Number 3, November 2012. Pp.125-130.

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