IOSR Journal of Applied Physics (IOSR-JAP)
e-ISSN: 2278-4861.Volume 7, Issue 6 Ver. I (Nov. - Dec. 2015), PP 11-14
www.iosrjournals

Design and Construction of Automatic Three Phase Power System Selector

F. U. Nweke and R. C. Iwu
Industrial Physics Department Ebonyi State Universiy, Abakaliki Nigeria

Abstract: *The automatic three phase power system selector was designed and constructed. The device automatically switches over to the alternative phase that has current when there is power outage or extremely low current in the phase which the load is connected without the power being off. The selector links the load and the other phases and relay switches allowing the usage of the remaining phases where there is outage on the mains source without disturbing or interrupting the load. It maintains constant power supply to the load by automatically activating the phases when the need arises. This safeguards the electronics system from being damaged and burnout as a result of voltage instability, collapse, insistent outages which are paramount in under developed and developing countries.*
Keyword: *Phase selector, Power system, Power system phase, Power instability, Voltage collapse, Power outages, relay and switches, comparator*

I. Introduction

In Nigeria today, the problems of power outage across phases is rampant thus leading to some sensitive equipment and appliances being kept without usage. Sometimes these equipments get damage or burnt as a result of insistent power outage resulting from the failure of one phase or the other. The power generation and supply in the country so insufficient to the demand by the consumers. The power lines are frequently overloaded resulting to a trip by the action of switch gears or the load shading processes undertaken by the distribution authorities known as Electricity Distribution Company, EDC (1, 2).

Power supply in Nigeria and in most developing and under-developing countries of the world is nothing to write home about. This has an adverse effect on the consumers of the electricity and the equipments that are operated from the main sources of supply. Electricity plays a major role in economic development of any nation but the supply keeps dwindling and sometimes not enough in Nigeria. The increase in urbanization, development and offshoot of industries and companies keeps adding to the power instability and collapse (1, 2)

Majority of industries in Nigeria suffer a lot of economic lost and revenue due to power instability and failure. Most of the time, the voltage supplied by the power companies is very low to power the engine. The power plants are subjected to usage of diesel engine to power them. This requires a lot of money keep the engine running. Also power instability and failure results to voltage surge and it results to equipment/engine failure or damage. Sometimes the impact of power disturbances and interruption on plant's equipment and processes caused by voltage sag may require a complete restart of engine with hours of interrupted production. This causes substantial economic loss to the industry (3, 4). Machines that are automated have suffered a lot of setback due to power instability and failure. Even quarter seconds voltage sag is sufficient to bring the modern machines to a screeching halt, resulting in hours of interrupted production and irrecoverable scrap (4). The cost and the depreciation associated with breakdown of equipment vary from one application to the other, and in some cases, the user has to spend huge amount of money to avoid voltage instability or collapse thereby embarking on alternative power supply. Hence, the depreciation caused by this instability reduces efficiency of organization and leads to great frustration (4).

II. Power System Phase Donations

The following phases are used in alternating current power transmission and distribution and are donated as:

(i) First phase , which is referred to as red phase
(ii) Second phase, which is referred to as yellow phase
(iii) Third phase, which is referred to as blue phase (2, 5)

Theoretical discussion

Electricity plays a major role in economic development of any nation. In most developing and underdeveloped countries, the supply of electricity for industries, commercial and domestic use is highly unstable. This gives rise to frequent use of alternative sources of power supply to meet up with the energy demand. The introduction of these alternative powers brings forth the challenges of smoothly and timely between the mains supply and the alternative sources whenever there is a failure on the mains source. Hence, there is need to reduce drudgery from switching between the two sources on the human side. The automatic three phase power selector automatically switches over to the alternative phases when there is power outage without the power being off. The automatic phase selector is a device that links the load and the other phases and relay switches allowing the usage of the remaining phases where there is outage on the mains source without disturbing or interrupting the load. The device maintains constant power supply to the load by automatically activating the phases when the need arises.

III. The Design Topology

The block diagram of the designed and constructed automatic three phase selector is shown in fig 1.

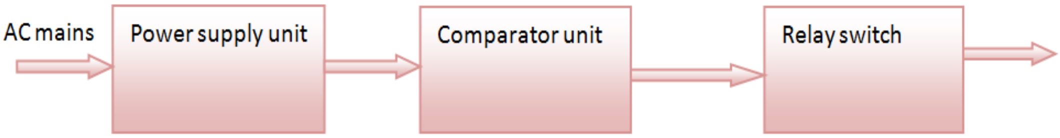

Figure 1: The block diagram of the designed and constructed automatic three phase power selector

The Power Supply Unit

Almost all the electronics equipment makes use of the direct current, dc voltage from either a battery cell or from alternating current, ac power line converted to direct current in the processes known as rectification. Most power supply is designed to convert high voltage ac mains electricity to a suitable lower voltage supply for electronics circuit and other devices with the use rectifier circuit. The ac power supply is stepped down with a step down transformer before the rectification using a diode. (6,7,8,9)

Design Calculations of the power supply Unit

In this design, $220V_{ac}$ is stepped down to $18V_{ac}$.

The transformer input voltage, $220\ V_{ac}$

The transformer output voltage, $18\ V_{ac}$

The transformer current in primary winding, $I_p = 200mA$

The transformer current in secondary winding, $I_s = unknown\ to\ be\ determined$

Using the expression

$$\frac{voltage\ in\ the\ primary\ winding,\ V_p}{voltage\ in\ the\ secondary\ winding, V_s} = \frac{current\ in\ the\ secondary\ winding, I_s}{current\ in\ the\ primary\ winding, I_p}$$

Where $V_p = 220V, V_s = 18V, I_p = 200mA$

$$\therefore\ I_s = \frac{V_p \times I_p}{V_s}$$

$$I_s = \frac{220 \times 0.2}{18} = 2.44A$$

Therefore, the current of the transformer secondary current, $I_s = 2.44A$

The rectifier circuit is a bridge rectifier circuit, which uses four IN4001 diode. The bridge rectifier circuit is a full wave rectifier circuit that converts alternating current to direct current since almost all user electronic garget uses direct current. The design calculation is thus

The maximum instantaneous voltage between the terminals of the rectifier circuit is thus:

$$V_{max} = V_{rms} \times \sqrt{2}$$

$$V_{max} = 18 \times 1.4142 = 25.46V$$

This is desired circuit voltage which is expected to swing from $-25.46V\ to\ 25.46V$.

From circuit of fig 2, d. c output voltage, $V_{dc} = I_{dc} \times R_L$

Where $I_{dc} = dc\ output\ current$ and $R_L = load\ resistance$

In full wave bridge rectifier, $I_{dc} = \frac{2V_{max}}{\pi R_L}$

Therefore

$$V_{dc} = I_{dc} \times R_L = \frac{2V_{max}}{\pi R_L}$$

Also $V_{dc} = \frac{2V_{rms}}{\pi} = 0.638V_{max}$

Then, the peak inverse voltage is given as $2V_{max} = 2 \times 25.46 = 50.92V$

Note, the output of the rectified circuit is smoothened to remove alternating current ripples by using filter circuit, by connecting a capacitor across the output of rectifier circuit (10).The purpose is to get a pure direct current necessary to power our electronics garget. The designed bridge rectifier circuit is shown in figure 2.

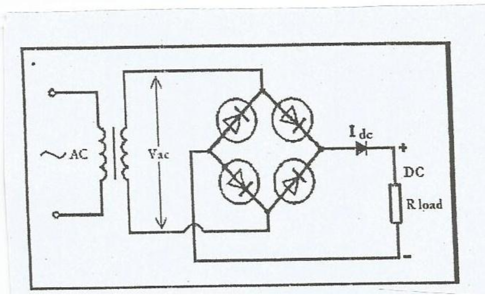

Figure 2: The Bridge rectified circuit

Comparator Unit

This unit compares two voltage signals and determines which one is greater. The result of the comparison is indicated by the output voltage. If the output op-amp voltage is saturated in the positive direction; the non-inverting input (+) is greater or more positive than the inverting input. If the op-amp voltage is near the negative supply voltage (i.e. 0 volts), or ground potential, it means the inverting input has a greater voltage applied to it than the non-inverting input (6,7,8, 11).

The Relay Switch

These are used for switching operations. This has contact points which form the normally open and normally closed switches. It also has energizing coil through which the switching contacts can be pulled together or drawn apart to effect the open and close operations. If current enters through the coil of the relay, the metal core becomes magnetized and attracts a strip of metal which closes the contacts that forms the open switch and the switch then become open. If the energizing voltage demagnetizes the metal coil, the metal strip is released to open the terminal and closes the terminal again (6,7,8).

Working principles of the designed automatic three phase selector

If the phase selector is connected to the main power supply say, red phase R; it is stepped down by transformer X_1 to deliver 12 V, 300mA, which is ratified by diode D_1 and filtered by capacitor C_1 to produce the operating voltage for the operating amplifier IC_1. The voltage at the inverting pin 2 of Op-amp IC_1 is taken from the voltage divider circuit of resistor R_1 and the preset resistor VR_1 is used to set the reference voltage according to the requirement.

The reference voltage at non-inverting pin 3 is fixed to 5.1 V through zener diode ZD_1. The voltage at the inverting pin 2 of IC_1 remains high (i.e. more than reference voltage of 5.1 V) in as much as the voltage in Red phase is in the range of 200-230 volt and its output pin also remains high. As a result, transistor T_1 does not conduct; relay RL_1 remains de-energized and red phase, R supplies power to the load L_1 via normally closed contact of relay RL_1. Moreover, as soon as phase R voltage goes below 200V, the voltage at inverting pin 2 of IC_1 goes below reference voltage of 5.1 V, and its output goes low. Then because of this, transistor T_1 conducts and relay RL_1 energizes and load L_1 is disconnected from phase R and connected to yellow phase, Y through relay RL_2. Similarly, the automatic phase changing of the remaining two phases, through yellow phase and blue phase, B works accordingly. The designed circuit and the truth table for the three phase power selector are shown in figure 3 and table 1 respectively.

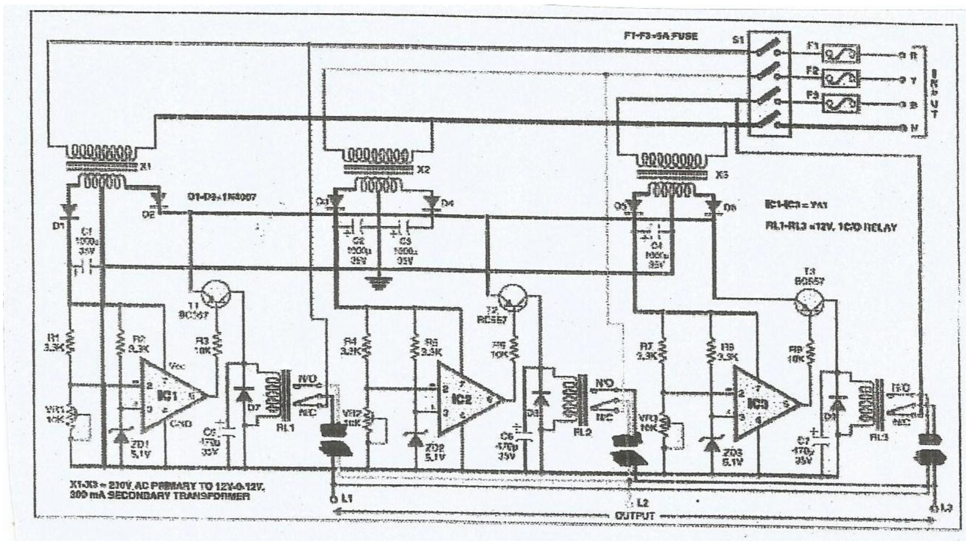

Figure 3: The circuit diagram of the designed three phase power selector

Input Red Phase, R	Input Yellow Phase, Y	Input Blue Phase, B	Output Voltage
0	0	0	No Supply
1	0	0	Phase R
0	1	0	Phase Y
0	0	1	Phase B
0	1	1	Phase Y or B
1	0	1	Phase R or B
1	1	0	Phase R or Y
1	1	1	Phase R or Y or B

IV. Conclusion

The automatic phase selector was designed and constructed to automatically select any phase that has current without affecting the load. The device reduces the possible of power being off completely in case of power failure in any particular phase if users connect their electronics garget to it. This was tested and it worked perfectly.

References

[1]. Nweke F. U., Anyigor I. S., Ekpe J. E. and Egba E. I. (2012). Essentials of Electricity Generation, Transmission, Distribution and its Hazards. International Journal of Advancement in Physics. Vol 4. Number 1. Pp 55-56

[2]. Nweke F. U. (2010). Workshop Processes and Practice: Electronics and Electrical Installation. IZU Prints Abakaliki Nigeria

[3]. Guasch L., Corcoles F. and Pedra J. (2000). Effects of Unsymmetrical Voltage Sag types E, F and G on Induction Motors. Proceedings of the conference on Harmonics and Quality of Power 3(3) 796-803

[4]. Greenfield J. D. (2006). Practical Digital Design using Integrated Circuits. New York. John Willey and Sons Incorporation.

[5]. Gupta B. R. (2001). Principles of Electrical Engineering. 96th edition S. Chad & Company LTD, New Delhi.

[6]. Boylestad R. and Mashelskey I (1996). Electronics Devices and Circuit Theory. New Jersey, USA Prentice Hall Inc.

[7]. Theraja B. L. and Theraja A. K. (1997). A Text book of Electrical Technology. 25th edition. Chad & company Ltd, Ram and Nagar, New Delhi

[8]. Giogio Rizzoni (2004). Principles and application of Electrical Engineering 7th edition. McGraw Inc.

[9]. Nweke F. U. (2014). Electronics Principles and Applications. IZU Prints, Abakaliki Nigeria

[10]. Conway G. A. and Jones K. I. (2002). Harmonic current produced by variable speed drives with uncontrolled rectifier inputs. IEEE Colloquium on three phase LV Industrial Supplies: Harmonics pollution and Recent Developments in Remedies.

[11]. Leon-Garcia B. (2000). Fundamental Concepts and Key Architectures of Electronics Circuit Design. Boston, USA. Mc-Graw Hill.