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DESIGN OF AUTOMATIC CHANGE OVER SWITCH WITH GENERATOR CONTROL MECHANISM

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ABSTRACT

Power supply in Nigeria and most developing countries of the world is anything but stable. This has adverse effects on the consumers of the electricity and the equipments that are operated from the mains sources of electricity supply in these parts of the world. In this paper, we 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. This mechanism has been tested and we recorded a great result. It thus holds an important key in the provision of a continuous power supply through a near seamless switching between the mains supply and an alternative standby source like the generator set.

Keywords: Power Supply; Alternative Power Source; Change-over Switch; Generator

INTRODUCTION

Electricity (energy), which plays a major role in economic development of a nation, forms the basis of this study, with interests in human, infrastructural and economic development. In most developing and underdeveloped parts of the world, the supply of electricity for industrial, commercial and domestic use is highly unstable. This gives rise to the frequent use of alternative sources of power supply to meet up with the energy demands. The introduction of these alternative sources of supply brings forth the challenge of switching smoothly and timely between the mains supply and the alternative sources whenever there is a failure on the mains source. There is also the need to reduce drudgery from switching between the two sources on the human side. Solving these challenges forms the focus of this work. The Automatic Change-over switch, automatically switches over to the alternative source of power supply (generator) when there is a power outage. It equally switches over to the mains supply when power is restored and turns off the generator automatically. The automatic power change-over switch is a device that links the load and mains supply or the alternative supply together. This enables the use of either the mains supply or an alternative source when there is outage on the mains source. This can either come in with three phase or single phase. This device maintains constant power supply to the load by automatically activating the generator when there is need. Since the user might not always be in need of the generator, provision has been made to prevent the generator from starting should an outage occur.

We can't go on and on to emphasize the importance of power supply to our home and industries, but it is important to mention that the outage of power supply can bring discomfort in our homes and loss of revenue due to down time in the industries. Thus Tony Rudkin, the author of 'upgraded signal source with improved performance and reliability', states that the cost and the depreciation associated with breakdown vary from one application to the other, and in some cases, the user has little choice but to ensure that a stand-by unit is available to take over on event of failure of primary system. Also in his book, he went further to say that the depreciation caused by such instability reduces efficiency of the organization and leads to a great deal of frustration. Sequel to the rate at which more sophisticated electrical/electronic gadgets are being procured and installed in our homes, hospitals and business premises, there is a justifiable need for a faster and more reliable change-over system in an event of power outage.

Therefore, in view of these considerations, in this project, we aimed at designing and constructing a workable automatic change-over switch with generator starting/shut down functions. This switch turns ON the generator automatically in cases of mains power failure and connects the load to the generator output, alternatively it switches OFF the generator automatically once power is restored and returns the load to the mains power. Thus, in the cause of finding solution to switching over to the alternative sources of supply without delay, undue wear and tear of the man who effects the change to the alternative sources come the importance of our research work.

THE STAND-BY POWER UNIT (GENERATOR)

The stand-by generator set is commonly used to supply emergency power to most of the power consumers where the mains supply is unstable. For best performance of the system, we must put into consideration the type of generator, engine type, its cooling system and fuel, the load capacity and the operating environment. Whatever cooling system is used to cool the generator, it is recommended that the heated air be channeled outside through an exhaust pipe while provision should be made to bring in fresh air so that the generating room, where the generator is installed, can be kept from becoming excessively hot, as this might cause damage to the engine of the generating set. Furthermore, the lubrication of the set is much important; the recommended lubricant should be used in order to maintain smooth and prolonged life span of the set by reducing wear and tear of the engine and other parts due to friction. Finally, it is important to determine the correct rating of the mechanical engine to drive a given generator so that it has the minimum capacity necessary to supply the selected load.

FEATURES OF GENERATOR TO BE USED ON AUTOMATIC CHANGE OVER SWITCH

The automatic change-over switch can be used in any place where alternative power is needed to complement the main power supply. In this project, a generating set is used as an alternative power supply. Thus, it is very important to note the necessary peripherals to be used with the automatic change-over switch.

(a) The generator must have electrical 'start and stop' facility.
(b) The generator's battery has to be in good condition always.
(c) The inter-connecting cables must be in good order

DESIGN CONSIDERATION

In designing and construction of this change-over switch, a generator with the capacity of 12KVA was used and its rating determines the ratings of the components and circuit elements to be used. It does not function with a faulty generating set and the generator must have a manual starter and engine stopper which is a *sine quo non* to the function of the automatic change-over. This automatic change-over switch is designed and constructed with the aim of achieving the following automatic actions.

a. To automatically switch on the generator and switch over the load to the generator whenever there is mains power failure.
b. To automatically switch over to mains supply once restored and simultaneously switch off the generator

However, a good switch should be the one whose contact is made in such away as to limit the arc formation by having no contact-bounce and by having contacts made of good conductive, corrosion resistance and wears resistance materials. Change-over switch must have adequate insulation and must be so contracted and located as not to constitute a potential hazard. A good change-over switch should also have tight contact points so as to limit or eliminate the possibility of partial contact at the contact point. The partial contact may lead to fire outbreak or possible damage to the contactor itself.

The following are the advantages that are associated to the change-over switch.

i. It minimizes damages to lives and equipment since it has its own monitoring system and its switching requires no human contact with the switch, thus eliminating human error.
ii. It reduces change- over time to a minimum, due to its fast response to power restoration
iii. It maintains high quality of service through its fast and prompt response.

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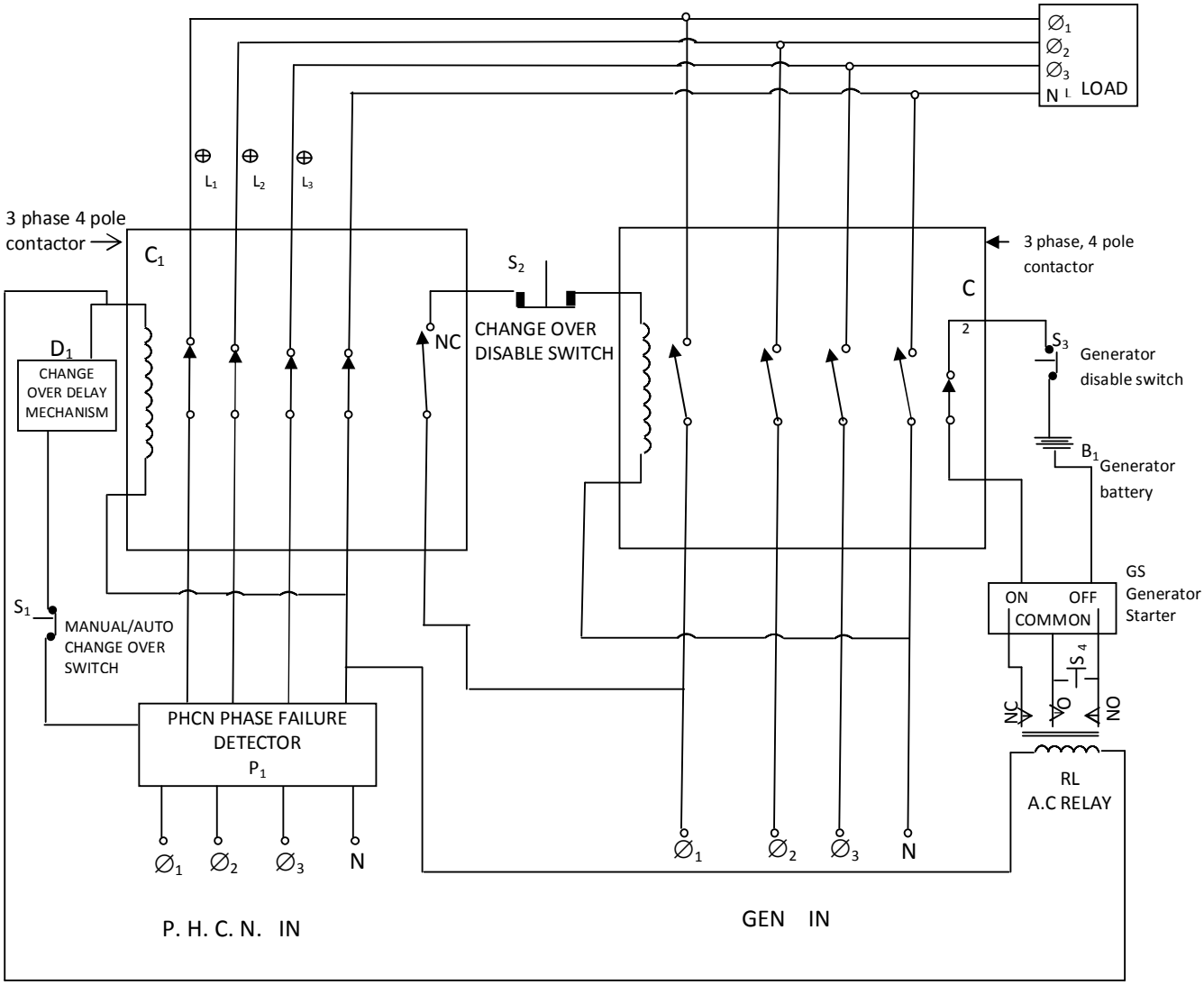
iv. Moreover, the unit is portable, easy, convenient and safe to install.

CIRCUIT DIAGRAM 3- PHASE AUTOMATIC CHANGE OVER WITH GENERATOR CONTROL



CALCULATION OF POWER FOR A THREE PHASE SYSTEM

If the change over is to be applied on a 220V/415V, 12KVA generator operating at 50Hz and a power factor of about 0.8.

To determine rating of contactor to be used as well as cable size

Recall

Apparent powers = 12×10^3 VA (12KVA)

Line voltage = V_L = 415V

Phase voltage = V_{SP} = 240V

Active power "P" = Apparent power x power factor

= $12 \times 10^3 \times 0.8$

= 9.6KW

Assuming a balanced load is being used,

$P = 3 I_P VP \cos \varnothing$

$9600 = 3 \times I_P \times 240 \times 0.8$

$$I_P = \frac{9600}{3 \times 220 \times 0.8} = 18.19A$$

$I_P \approx 18.3A$

The contactor required will have a minimum current rating of 18.3A

For increased efficiency a tolerance of about +25% will be given

Thus contactor rating will be

$$18.3A + \frac{(25 \times 18.3)}{100}$$

$= 18.3 + 4.6$

= 22.9Amps or nearest allowable.

Ip = 18.3 deduced is current per phase. Thus any cable used should be capable of carrying about 1½ times the current. The operating environment will also play a role.

:. Required cable should carry a current of at least

18.3 + (50% x 18.3)

= 18.3 + 9.15

= 37.45Amps

However, if the operating environment is very hot, a larger cable size will be required.

COMPONENT LIST

C_1 & C_2	-	3 phase and neutral (4 pole) 250v, 50Hz contactor with extra Normally close contact
D_1	-	Delay switch
P_1	-	Phase failure detector (3∅)
RL	-	250v, 50Hz A.C Relay
GS	-	Generator starter mechanism
S_1, s_2, S_3	-	250V, push and hold switches
L_1, L_2, L_3	-	250V, 50Hz pilot lamps

DESCRIPTION OF AUTOMATIC CHANGE OVER WITH GENERATOR CONTROL MECHANISM

The 3 phase automatic change over with generator control mechanism is a system designed to select between two available sources of power giving preference to one out of the two sources.

In this case, the selection is between Power Holding Company of Nigeria (PHCN) and a generator. The system monitors the PHCN mains supply and checks for complete failure and phase failure upon which it changes over to the generator supply starting the generator automatically and switching it off automatically when proper mains supply is restored. The circuit diagram attached above shows the circuit condition when PHCN mains supply is available.

The PHCN supply is fed through a 3 phase failure detector P_1. The phase failure detector monitors all three phases to ensure appropriate supply of mains power. If all three phases are powered, the phase

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failure detector connects them to C_1, a 3 phase four pole contactor, whose output is connected to the load. Simultaneously, it also feds appropriate voltage to the coil of C_1 via a delay mechanism, D_1. Once contactor C_1 has been energized, it feeds power to the load. C_1 has an additional "normally closed" contact (NC) in it. This contact opens when C_1 is energized and also controls the voltage to the coil of C_2. As long as this contact is open, C_2 which controls the generator output stays de-energized. Thus separating the generator output from the load, hence, preventing a clash between both sources. Also, the output voltage from D_1 is used to energize a 220V AC relay (RL) which controls the generator starting mechanism. As long as RL is energized, the generator is made to stay in the off position. Thus, with proper mains supply, the generator remains off and only the mains supply is connected to the load. In the absence of an AC relay for RL, a DC relay can be used but with appropriate rectified voltage been fed to it. If however, a phase failure or complete power failure occurs in the PHCN line, the phase failure detector P_1 will cut off power thus de-energizing C_1 and RL. As a result off this, the normally close contact of C_1 closes, connecting the coils of C_2 to the generator output. In like manner, the PHCN main is disconnected from the load. C_2 is not yet energized because the generator is yet to start. However, the time for which this occurs is small as RL, once de-energized, connects the generator starter to the battery causing the generator to start. Once it has gathered momentum and has built up sufficient voltage, C_2 becomes energized (since its coil is energized by the generator output). This cause C_2 to activate and connects the load to the generator output, thus, restoring power automatically. The normally closed contact of C_2 is used to disconnect the battery from the starter to prevent it from running down when the generator is running.

Once power is restored, the delay mechanism D_1 prevents change over back to PHCN from occurring until after a preset time. This time is kept to ensure that the mains power supply is stable. Once the time elapses, D_1 energizes C_1 and RL simultaneously. This causes the normally close contact of C_1 to open and thus de-energizing C_2 and disconnecting the load from the generator supply. At the same time, C_1 being energized connects the load to PHCN supply. In like manner, RL switches the generator ignition to its off position.

S_1 is used to make a manual change over when pushed open. It does so by disconnecting power from the coil of C_1 thus de-energizing it as though there were power failure; hence, the change over process as explained above takes place as.

S_2 is used to prevent change over to generator by disenabling C_2. Thus, whether the generator is running or not its output is not fed to the load. This is necessary when it is required to steam the generator engine.

S_3 is used to keep the generator off even when change over occurs. This is useful in times when the user does not want the generator to be used.

S_4 is used to turn the generator off when in use but power has not been restored. It is not a push and hold switch. L_1, L_2 and L_3 are pilot lamps used to monitor the output voltage.

The rating of the change over depends on the rating of the contactors. In addition, a sound and functional generator with battery starting ability is recommended.

CONCLUSION

Automatic change over switch with generator starting/shut down facility has been designed to help man reduce the stress and loss of time associated with the starting and shutting down of the alternative sources of supply (generator). It is worthy to note that this project is subject to scrutiny and further development. I recommend that for future development an overload protection system be included. I also recommend this project to the entire field where electricity is highly needed and even to the small and medium entrepreneur that the automatic change over switch with generator starting/shut down facility will help them. To the government, I recommend they encourage the mass production of this project.

REFERENCES

Hammond, R. (1968). Development of electric traction. *Modern Methods of Railway Operation*. London: Frederick Muller. pp. 71–73. OCLC 467723.

http://en.wikipedia/org/wiki/protection.

http://www.nema.org/engineering/icsstandards.html

Internet http://.en.www.kree/uk.com

Itt://www.ssac.com/motor/deftermp.htm

Nagrath, I. J. Kothari, I. D. P. (2000). *Power System Engineering*, New Delhi: Tata, McGraw Hill Publishing Company Limited.

Peter, U.O. (2002). *Power system protection,* AAU Ekpoma.

Ragnar, H. (1958). *Electric Contacts Handbook*. 3rd Edition, Springer-Verlag, Berlin / Göttingen / Heidelberg. pp. 331-342.

Ransome-Wallis, P. (1959). Electric motive power. *Illustrated Encyclopedia of World Railway Locomotives*. London: Hutchinson. p. 173.

Shephard, J. Morton, A.H. and Spence, L.F. Higher Electrical Engineering

Terrell, C. and Wilford, S. (ed), (1987). *American Electricans' Handbook,* Eleventh Edition, New York: McGraw Hill, page 7-124.

Theraja, B.L. and Theraja, A.K. (1995). *Electrical Technology,* Delhi: Publication of Ram Naogar.

Thomas, P.H. Networks of power, Electrification in western society1880-1930, the johns Hopkins.

Thomas, P.H. Networks of power, Electrification in western society1880-1930, the Johns Hopkins.

www.easa.com/indus/stator10.hml