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**Elimination of Stress and Reduction in Switching Time From Mains to Back-Up Power  
Source in Power Dependent Public Utilities by Automatic Mains and Phase Changer**

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**Abstract**

Most public utilities depend on electric power to function, so it is paramount that a constant power source is available. These public utilities get their supply from the public mains and in the case where the public mains fails a back-up power source is necessary to ensure the continuous operation of the public utilities. Switching the public utilities from the mains to the back-up power creates a period of time when the utilities will be without power and the longer the time delay the lesser the efficiency of the public utilities. The stress of manual switching also makes the utilities inefficient. Examples of these public utilities are street lights, traffic lights, water pumps and traffic sign indicators.

A device that completely eliminates the stress of manually switching public utilities from the mains supply to the back-up supply is the Automatic Mains and Phase Changer (AMPC). It also greatly reduces the power outage time delay experience during the switching.

This paper reports a research that evaluates the relationship between the stress levels during manual load switching and the stress levels using the AMPC for automatic load switching. It also evaluates the relationship between the time lag experienced with the use of the AMPC and the time lag experienced when the switching is done manually.

The research involved the use of an AMPC to automatically switch from one of the phases of the 3-phase mains supply that has failed to an available phase of the same mains supply. The time lag experienced between switching when it is done automatically with the AMPC was recorded and compared with the time lag experienced when the switching is done manually. With the load being single phase, it can be switched between the phases of a 3-phase mains supply depending on which phase is available.

The research also involved the use of the AMPC to provide automatic switching from the mains power supply to a back-up or generator supply. The time-lag in the automatic switching using AMPC was compared with the time-lag when the switching was done manually and the relationship between the time-lags was fully analyzed and evaluated in this paper. 20 time-lag readings were taken with the AMPC used and with the switching done manually and the analysis of the relationship between the time-lags as well as the relationship between the stress levels of both, is well documented in this paper. The result of this research showed that change-over time is greatly reduced with the AMPC, compared to manual change-over time which depends on the position of the operator relative to the position of the change-over switch.

**Keywords:** power outage time-lag, power failure, Automatic mains and phase changer, automatic switching, manual switching, power source.

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**Introduction**

Power failure has proven to be one of the major factors limiting the amount of goods and services produced by industries and firms, which in turn limits economic growth (Oladokun, 2013). Being in or around cities has special consequences for power outages as public utilities will be largely affected. Urban and suburban areas are highly dependent on electricity. There are several of the areas that electricity directly impacts. As can be

experienced at any time the traffic lights in an area are not functioning, traffic flow will be slowed down and can become dangerous when people become flustered and rushed. Most individuals will behave responsibly and politely when trying to cross nonfunctioning traffic lights. However it only takes a few people acting irresponsibly to cause collision. Small areas affected by power outages for a limited time pose a very small risk. Larger areas affected by

outages can have a much greater effect on traffic congestion. Consider how a single accident at an intersection can affect traffic in several directions for considerable distances. Then consider how as the auto accidents start to multiply how it will affect traffic congestion to a larger degree. (Phloydius, 2008)

For some equipment, a reliable uninterruptible and free of disturbance power supply is an absolute need. From this point of view, a fault in the power supply of communications systems, hospital apparatus, security systems, water and gas distribution devices, banking computers and many other crucial appliance may bring about serious problems, with consequences that can easily be imagined. All these applications can be identified as critical power applications: they are specifically designed to leverage a constant and secure power supply

Power instability or outage in general does not promote development in the public and private sector (Robert, 2010). Pumping machines at petrol stations are electrical machines and they will be affected by power failure which in turn affects transportation in cities as most vehicles use petrol as a source of energy. Also, public water systems are controlled by huge electrical pumps meaning the longer the power outage time the longer the period where the pump is non-operational. When the pumping station stops pumping, the water stops flowing. Any water remaining in the pipes may flow down hill (with gravity only) to homes at lower elevations. Additionally water systems that are closed in a vacuum may not flow as easily or at all with no pressure from the pump (Phloydius, 2008). This shows that power outage time affects public water distribution.

To limit the effects of power failure on the economy of a nation, back-up power supplies are paramount. A device to provide an almost instantaneous switching from the mains power supply to the auxiliary/back-up supply when there is power failure in the mains supply is also important to reduce the effects of power failure. This device is called an Automatic Mains Failure (AMF). The AMF is composed of series of relays and timers and automatically transfers an electrical load from the primary power supply (e.g. Power Holding Company of Nigeria (PHCN)) to a back-up power supply e.g. generator (Oladokun, 2013). The AMF continually monitors the level of voltage at the main supply till it fails (Saiful, 2008).

Most countries, including Nigeria, utilize 3-phase 4-wire lines for power transmission to homes and industries. Most industries will utilize the entire 415V line voltage from the 3-phase 4-wire power

transmission for the operation of 3-phase machines such as 3-phase motors and rotary fillers. But for domestic use in homes and establishments such as banks, hospitals, hotels, and computer centers where single phase machines and electronic devices are used, only 220V phase voltage is needed. Despite the need for just 220V phase voltage, most homes, banks, hospitals and offices in Nigeria are connected to 3-phase 4-wire power supply. This is done because, sometimes power failure occurs in one or more of the phases making it necessary to have a cut-out fuse to transfer electrical load to any available phase. To eliminate the stress of manually switching between the phases and also reduce the power outage time between the switching, an electrical device known as an automatic phase changer is needed (Oladokun, 2013).

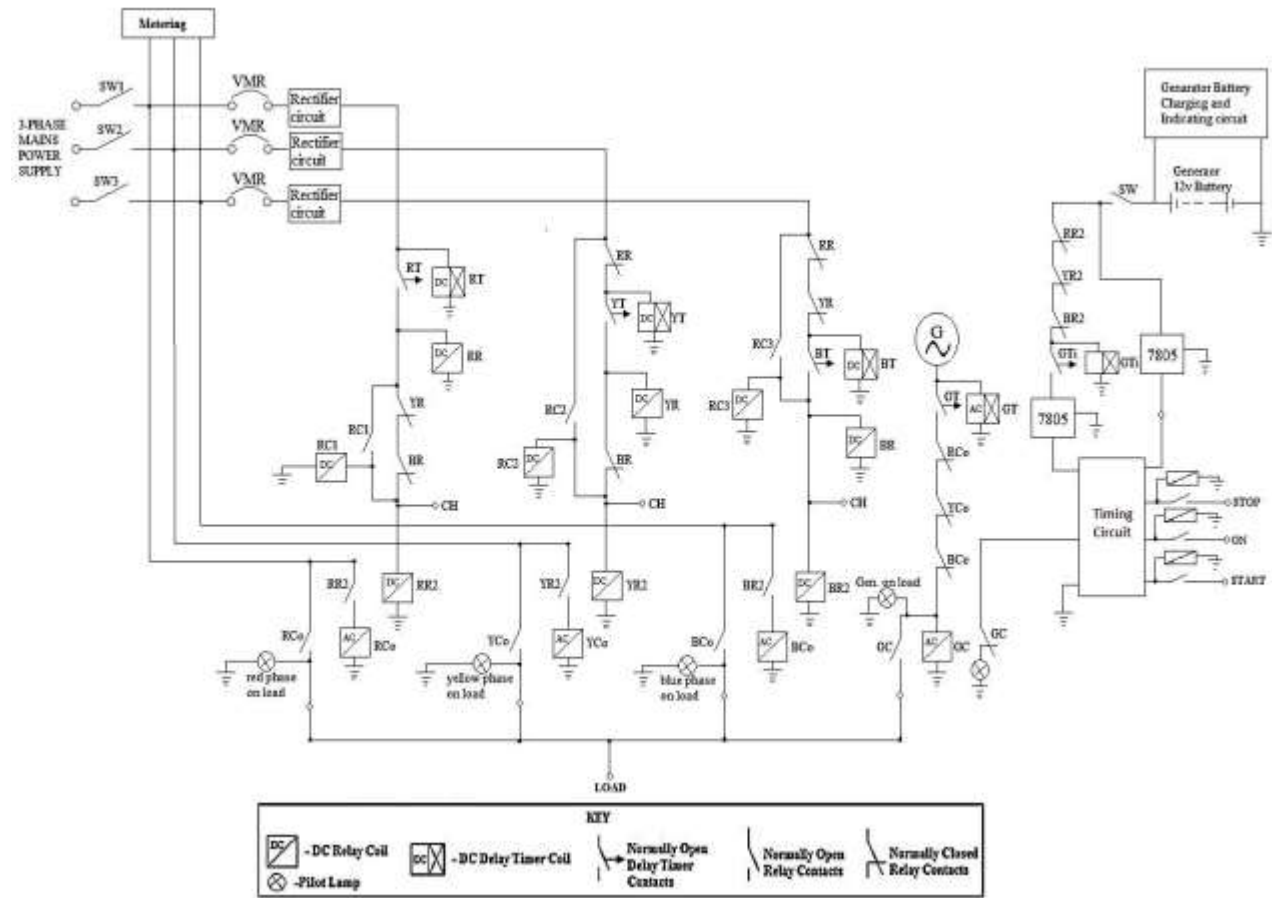
An automatic phase changer automatically transfers an electrical load from a phase when there is power failure in the phase to another phase with available power supply in a 3-phase 4-wire power system. The automatic phase changer can only be used in firms and establishments that utilize single phase devices or electronic devices such as banks, hospitals, hotels, cinemas, cyber cafes, and government secretariats. It is composed majorly of series of relays and timers, configured in such a way that it provides almost instantaneous switching between phases (Oladokun, 2013). An Automatic Mains and Phase Changer (AMPC) combines the function of an AMF and an Automatic Phase Changer.

It consists of a configurable automatic control associated with an emergency manual operation with on-load switch disconnecter providing safety isolation combined with high making and breaking characteristics (Socomer, 2014). One of the basic operations of the device is to switch ON an auxiliary power supply (like a generator). This operation connects the power supply from the generator to the load after a predetermined time interval. This is intended to normalize the current from the generator. Switching is possible through the use of the relays. The system was designed to automatically change power supply back to the main supply moments after the A.C. mains are restored and to switch OFF the generator (Jonathan, 2007). The AMPC monitors all three phases to ensure appropriate supply of mains power. If all three phases are powered, it connects them to a 3-phase four pole contactor, whose output is connected to the load (Ezema et. al, 2012).

**Methodology**

The methodology of this research involves the design, construction, development and incorporation of an Automatic Mains and Phase Changer. The incorporation of the Automatic Mains and Phase Changer involves the use of the AMPC to provide automatic switching between the phases of the mains supply and automatic switching between the mains supply and the generator/backup power supply. The main objective of this research is to

compare the stress levels experienced during automatic switching with the aid of the AMPC and the stress levels experienced when the switching is done manually, analyzing the relationship between them and drawing conclusions based on the analysis. Also the time delay during switching with the use of the AMPC and with the switching done manually are also compared and analyzed and conclusions are drawn from the analysis.



**Fig. 1: The full circuit diagram of the Automatic Mains and Phase Changer**

Fig. 1 shows the full circuit diagram of the constructed Automatic Mains and Phase Changer with the three phases of the mains supply connected to the SW1, SW2 and SW3 switches to enable emergency shutdown of a faulty phase. The metering circuit shows the voltage levels of the phases of the mains supply and the generator when it is turned ON.

The voltage of each phase is converted from 220v ac to 12v dc with the aid of rectifier circuits as the relays and timers used in the control circuit have ratings of 12v dc. As shown in fig. 1 the generator battery is charged by a 12v charging circuit to keep the battery's energy level constantly high. Fig. 2 shows the pictorial view of the AMPC.



*Fig. 2: Pictorial view of the constructed Automatic Mains and Phase Changer*

### Experiment

The AMPC was used to provide automatic switching of a model 500 watt single phase load between the three phases of the mains supply. Afterwards, the same process was done by manually switching the single phase load between the phases of the mains supply with the aid of cut-out fuses. Fig 3 shows the difference in the stress levels when the

switching is done automatically with the aid of the Automatically Mains and Phase Changer, and when the switching is done manually. As shown in Fig 3 when the switching is done manually the stress level is at Y joules, where Y is a positive natural number. When the switching is done automatically with the aid of the AMPC, the stress is completely eliminated meaning the stress level will be at 0 joules.

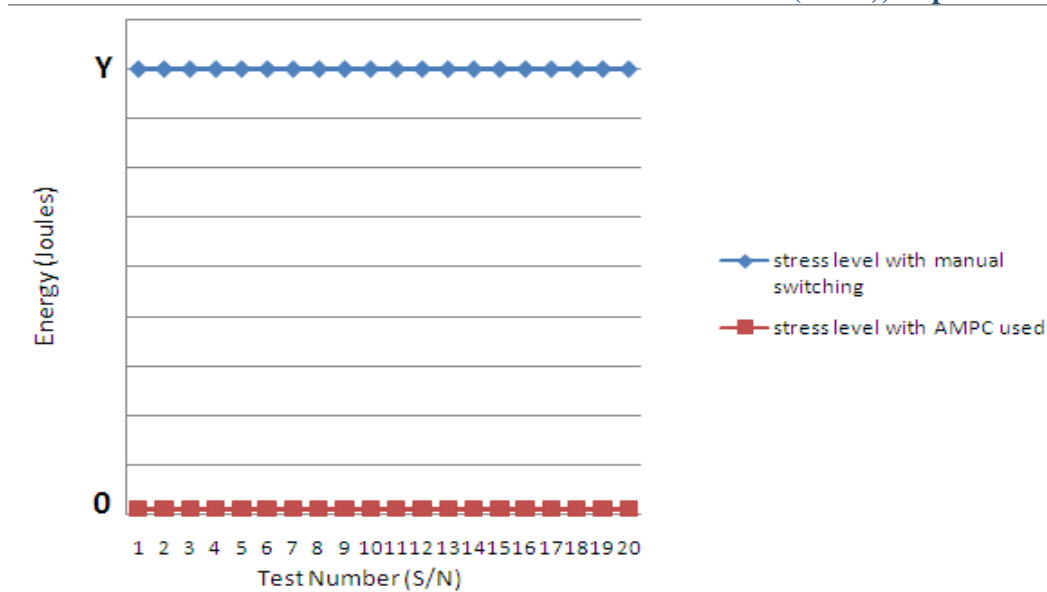


Fig. 3: Line chart showing the relationship between the stress levels of automatic and manual switching

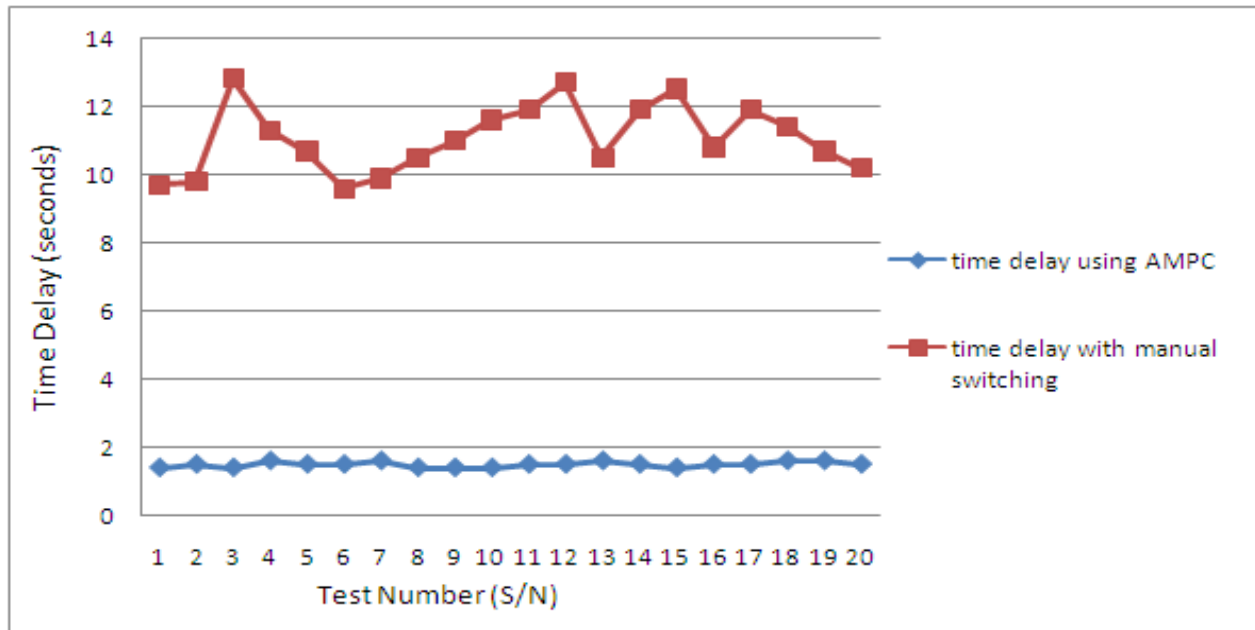
The time delay experienced during the phase-to-phase switching was recorded (with the aid of a stopwatch) with the AMPC used and with the switching done manually. The switching process with the AMPC and manual switching were repeated in 20 tries with the switching time delay readings taken each time. Meaning that 20 readings were taken with the AMPC used and 20 readings taken for manual switching. Table 1 shows these readings. As seen in Table 1, the time delay values with AMPC used are close as they range from 1.4 to 1.6 seconds. These

specific time delay values confirmed the pre-defined and set time in the timing circuit design to ensure all the phases do not get switched at the same time when they become available at the same time. The time delay values with manual switching are erratic and relative to the position of the operator from the switching center with the values ranging from 9.7 to 12.8 seconds. The readings for the manual switching were taken with the manual switches and cut-out fuse about 5.0 meters away from the operator for each reading.

Table 1: Comparison of Phase-to-Phase Switching Time Delay

S/N	Time Delay with AMPC used (seconds)	Time Delay with Manual Switching (seconds)
1	1.4	9.7
2	1.5	9.8
3	1.4	12.8
4	1.6	11.3
5	1.5	10.7
6	1.5	9.6
7	1.6	9.9
8	1.4	10.5
9	1.4	11.0
10	1.4	11.6
11	1.5	11.9
12	1.5	12.7
13	1.6	10.5
14	1.5	11.9
15	1.4	12.5
16	1.5	10.8
17	1.5	11.9
18	1.6	11.4
19	1.6	10.7
20	1.5	10.2





**Fig 4: Line chart showing the relationship between the phase-to-phase time delays for manual and AMPC switching**

The AMPC was also used to switch from the mains power supply when all the phases fail, to the generator power supply, automatically kick-starting the generator in the process. This process was carried out with a 500 watt model single phase load with 20 tries with the AMPC and 20 tries with the switching done manually and the generator started manually. Time delay readings were taken with the AMPC and with the switching and generator starting done manually. Table 2 shows these readings. The time delay readings with the AMPC used are close and range from 10.5 to 10.7 seconds with most of the delay due to the time it takes the generator to start, come up to speed and maintain a constant voltage

level. The time readings with the switching and generator starting done manually are greater than when the AMPC is used and are erratic and random, with the values ranging from 18.5 to 24.7 seconds. The randomness of the values is due to variations in how long it takes the operator to get to the generator’s location when the mains fails, which for this research is about 5.0 meters from the operator’s initial position, and how long it takes the user to start the generator. It also depends on how long it takes the operator to get to the switching box after the generator has started and manually switch the load from the mains to the generator.

Table 2: Comparison of Mains to Generator Switching Time Delay

S/N	Time Delay with AMPC used (seconds)	Time Delay with Manual Switching (seconds)
1	10.7	18.5
2	10.5	19.8
3	10.5	19.6
4	10.5	20.9
5	10.6	20.5
6	10.7	19.5
7	10.7	23.5
8	10.6	24.7
9	10.6	24.5
10	10.7	23.3
11	10.6	19.5
12	10.6	20.7
13	10.5	22.8
14	10.5	20.9
15	10.5	20.7
16	10.5	20.4
17	10.6	21.9
18	10.7	22.6
19	10.6	23.7
20	10.5	22.9

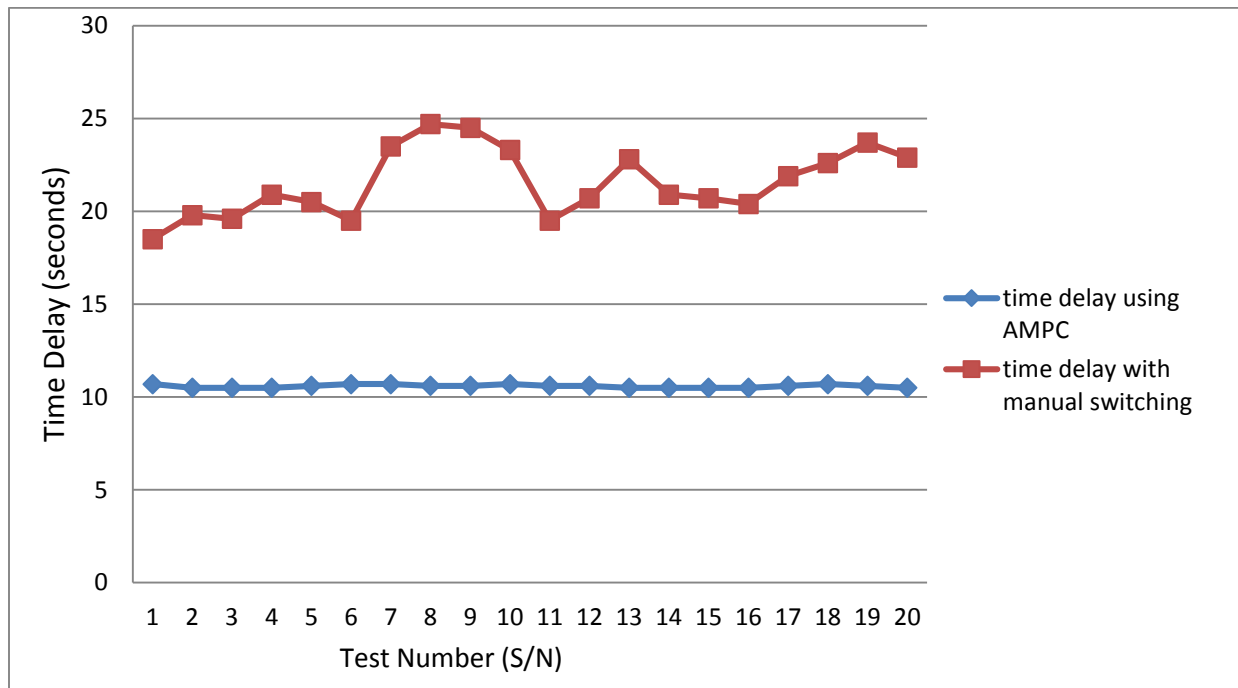


Fig. 5: Line chart showing the relationship between the mains to generator time delays for manual and AMPC switching delays with manual phase switching. As shown in fig. 4, the line for the phase-to-phase switching time delay with AMPC used, exists much lower in the

**Result discussion**

Fig. 4 is a line chart showing the relationship between the time delays with the AMPC used for automatic phase-to-phase switching and time

chart than the line of the manual phase switching as manual switching time depends on the relative position of the operator to the switch board. The time delay values for manual phase switching have a wide range of values as the speed of switching is dependent on the operator's physical speed and relative position. This is shown by the zigzag line in fig 4.

Fig. 5 is a line chart showing the relationship between the time delays with the AMPC used for mains to gen switching and the time delays with manual mains to gen switching. As shown in fig 5, the line for the mains to gen switching with AMPC is almost straight as the time delay values have a close range. These close range values are possible because the AMPC timing circuits have set time values. This is as opposed to the line for the manual mains to gen switching which has a wide range of values as switching speed depends on the operator.

### Conclusion

In conclusion, the difference between the time delay in automatic load switching and manual load switching is large enough to prove that automatic load switching makes public utilities more efficient and an Automatic Mains and Phase Changer is the most reliable device to achieve this.

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