NED UNIVERSITY OF ENGINEERING AND TECHNOLOGY

BASIC ELECTRONICS COMPLEX ENGINEERING PROJECT: Automatic Phase Changeover Circuit

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Scan to access simulation and supporting documents
Or visit:
https://github.com/huzaifa-2123/BEL-CEP

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Automatic Phase Changeover Circuit: *Report*

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***Abstract*— This research work is on the design and construction of automatic phase changeover circuit for 3-phase power supply. It is aimed at providing a means of switching from one phase of alternating current (AC) mains to another in the case of failure in the existing phase. This research was conceived with the intention of improving on the existing type of electromechanical devices that are currently in use. The result from the current research has shown the capacity to automatically switch power from national grid to generator and vice versa, once there is power failure in any of the two power supplies and at the same time has the capacity of shutting down a generator set once the mains grid is been restored and this has been achieved by the use of operational amplifier, timing circuit and high current relay switches.**

***Keywords*— Power, Selector, Current, Electricity, 3-Phase**

I. INTRODUCTION

Power instability and phase failure has become a serious problem in the developing countries like Bangladesh and Nigeria to improve their socio-economic condition. Almost all of the companies; Industrial, commercial and also domestic loads are run by the public power supply which associates different problems for example: imbalances among the phases, phase failure or sometimes complete power shut down occurs due to various types of technical problems occurred in the power generation, transmission and distribution system. Most of the power consumers use single phase equipment for operational purpose which is greatly affected if there is unbalance voltages, under voltages or over voltages. A significant amount of time would be required for manual switch over operation and as a result, serious trouble could be associated with the machines or in the production process. Moreover, a standby manpower would always be required to change over the supply voltage line. To overcome these challenges, Automatic phase changing system could be implemented. Here, an Automatic Phase Changer circuit has been simulated.

A. Advantage Over Traditional Method

Automatic phase changer finds wide application in modern world. During earlier days, if there was any power failure in any one of three phases occurred, it was required to switch to the available phase manually. By implementing automatic phase changer it automatically shifts to the phase where correct voltage is available. It can be used in residences, small offices, buildings etc. Automatic phase changer is a circuit of very compact design. This circuit is very cost effective. It is very easy to install too. Low maintenance is required for this circuit.

B. Objective of the Project

In three-phase applications, if low voltage is occurred in any one or two phases then to maintain normal voltage for the equipment this circuit can play an effective role. However, a proper-rating fuse needs to be used in the input lines (R, Y and B) of each phase. The circuit provides correct voltage in the same power supply lines through relays from the other phase where correct voltage is available.

C. Primary Objective

The primary objective is to make the automatic phase changer circuit which will work for under voltage fault in a three phase system and to show that by using this circuit, intensity & amplitude of voltage in the load side will remain the same before the fault occur.

D. Secondary Objective

The secondary objective is to show the simulation & to prove theoretically that the automatically phase change circuit actually works for over voltage fault.

II. LITERATURE REVIEW WITH APPLICATIONS

A. Necessity of Automatic Phase Changer

In three phase power supply line voltage can be dropped or risen from the rated voltage supplied in any phase for various causes. The reasons for voltage fluctuation are discussed below in brief.

Voltage rise: In case of transmission line is charged on no load- due to its capacitive effect voltage gets rise at receiving end more than that rated voltage.

Voltage drop: Due to active power loss or resistance of the line, IR drop occurs which result in getting less voltage at the receiving end which is less than the rated voltage. Another reason for voltage drop is that if heavy load is applied all of a sudden, voltage drop occurs.

Automatic Phase Changer circuit can provide nominal voltage to the emergency loads with the help of healthy line

B. Literature Review

This is a major characteristic of an AC electricity supply that requires explanation -phases. A DC circuit has two wires through which the current in the circuit flows from a source of electricity through a load and back to the source (Brittain J. E, 2007). A single-phase AC circuit also has two wires connected to the source of electricity. However, unlike the DC circuit in which the direction of the electric current does not change, the direction of the current changes many times per second in the AC circuit. The 220 volt electricity supplied to our homes is single phase AC electricity and has two wires - an "active" and a "neutral".

The distribution line supplying your home may be single phase and have only two wires strung between the poles (we will use the overhead power lines as examples because they can be easily seen). However, the distribution line may be made up of 4 lines. What are the others? The other lines carry the currents from two other electrical circuits, making a total of three circuits or phases. The reason why there are only 4 lines is because the 3 phases have a common neutral line (i.e. 3 active lines and 1 common neutral line) according to (Fowler, 2011).

Because the magnitude and direction of the electricity flowing in each of the phases is slightly displaced in time from the electricity flowing in the other phases, the current flowing in the common neutral will be the sum of the neutral currents from the 3 phases. The resultant current in the common neutral is smaller in a 3 phase system than in systems with other numbers of phases. This ability to use a common neutral of relatively small capacity has large economic advantages and is the main reason why 3 phases are used (Fowler, 2011).

Three phase electricity has another advantage. In Canada, the voltage between the active and neutral in the single phase, low voltage supply to our homes is 220 volts and that this phase is only one of the phases in the 3 phase system. The voltage between the phases of a 120/208V 3 phase system is 208 volts (in Canada). A 208 volt, 3 phase supply is able to deliver more energy than a 120 volt, single phase supply. 3 phase supplies are normally restricted to large electrical loads, such as large electric motors. Commercial buildings are often wired for three phase power. Air conditioners for instance are run on the three phase power while single phase power is typically used for most electrical, electronic and lighting equipment.

A single phase supply must have a neutral, whereas a 3 phase supply does not require a neutral. More complicated reasons deal with fixing the voltage of the single phase supply relative to the ground (because domestic appliances have their metal enclosures connected to ground) and for fault protection purposes. 3 phase, medium voltage, distribution systems and high voltage transmission systems therefore use one wire for each phase and no neutral (Fowler, 2011).

The above discussions focused on active and neutral conductors (wires) as being the means to convey the electricity. One type of system uses the ground as the return path, with only the active being conveyed by a wire conductor. This type of single-phase supply system is called the Single Wire Ground Return system and is use to supply small loads which are located far from the main distribution networks (Brittain J. E, 2007).

C. *Previous Research & Innovation*

Indian Engineer M. Patel’s 2008 design (published in IEEMA Journal) used interlocked relays to ensure:

1. Phase-1 was always the first choice.

2. If Phase-1 failed, Phase-2 took over without timer delays.

3. Phase-3 acted as a last resort.

- Impact: Reduced switch time to under 2 seconds- critical for flour mills and cold storages.

D. *Real-World Applications*

1. *Homes:*

- Protects Appliances
- Eliminates the need for manual generator switching
- Keeps security systems active

2. *Hospitals:*

- Ensures uninterrupted power
- Prevents data loss
- Reduces stress on medical staff

3. *Industries & Factories*

- Prevents costly downtime
- Protects heavy motors
- Smart systems prioritize phases

4. *Offices & IT Companies*

- Seamless phase switching keeps computers and servers running
- Prevents data loss in cloud services and data centers
- Maintains Productivity

5. *Rural Areas & Remote Locations*

- Provides consistent power
- Supports irrigation pumps, cold storage, and small industries
- Reduces dependences on expensive diesel generators

III. METHODOLOGY:

The design and execution of Automatic Phase Changeover Circuit comprises both hardware and software components to guarantee constant power supply by automatically switching to an available phase when an active phase fails. The methodology consists of:

A. *System Design*

The circuit is built to observe three-phase (R, Y, B) supply lines and detect the presence and absence of the phases respectively. Relay modules automate phase switching without manual intervention.

B. Phase Sensing and Relay Controlling Circuit:

Each of the phase lines (L1, L2, L3) is connected to a voltage sensing circuit and relay control circuit. AC Voltage is first stepped down by Transformers (TR1, TR2, TR3) respectively on each phase line, then rectified using a rectifier (D1-D2, D4-D5, D7-D8), and smoothed by a capacitor (C1, C3, C5). Zener diode regulates the voltage. An operational amplifier (U1, U2, U3) is used to detect the voltage presence. In the presence of voltage, the operational amplifier triggers a transistor (Q1, Q2, Q3), which powers a relay (RL1, RL2, RL3). The relay then controls a separate load, indicating the status of the corresponding phase.

C. Transistor-Based Relay Activation Circuit

The outputs given by the operational amplifier are connected to transistors that run the relays. To protect the transistor from back EMF by the relays, diodes (D3, D6, D9) are used. Each relay links to one of the three phases (L1, L2, L3). The operational amplifier's output determines which relay is activated at a given time, ensuring that the load is connected to one phase at any given moment.

D. Relay-Controlled Phase Selection

Relays are used to connect the chosen phase to the load. Proper interlocking and logic within the operational amplifier and transistor control ensures that only one relay works at a time, preventing phase short-circuiting or simultaneous connection of multiple phases.

E. Circuit Validation and Performance Analysis:

The complete circuit is tested under various simulated conditions, which involves phase voltage changes and intervals, to evaluate its performance. Observations are made with respect to the switching speed of the relays, the reliability of the transistor-based activation, and the correctness of the phase selection logic implemented by the operational amplifiers. Load stability and automatic switching to the active phase are confirmed to guarantee healthy and stable operation.

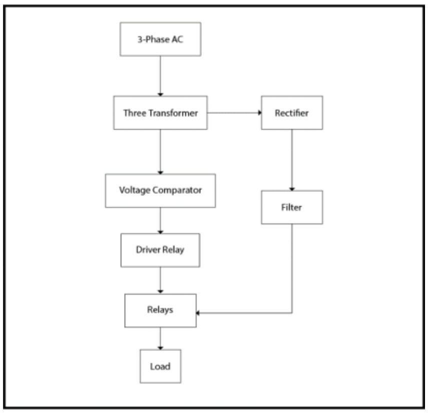

Figure 1: Block Diagram "Working of an APCC"

F. Need and Impact of Zener Diode and Op-Amp Connections:

Zener diode and Op-amp connections play an important role in voltage regulation and phase detection.

1. *Need*

Zener diodes provide a stable reference voltage and protect sensitive components like Op-Amps from overvoltage.

Op-Amps function as comparators, comparing rectified AC voltages to the reference and converting analog signals into digital logic for controlling relays or microcontrollers.

2. *Impact*

Zener diodes limit rectified AC signals to a safe threshold, ensuring accurate phase detection and protecting Op-Amps from voltage spikes. Op-Amps detect and prioritize the correct phase for load switching, improving reliability, precision, and reducing the need for manual intervention.

IV. Circuit Schematics and Components

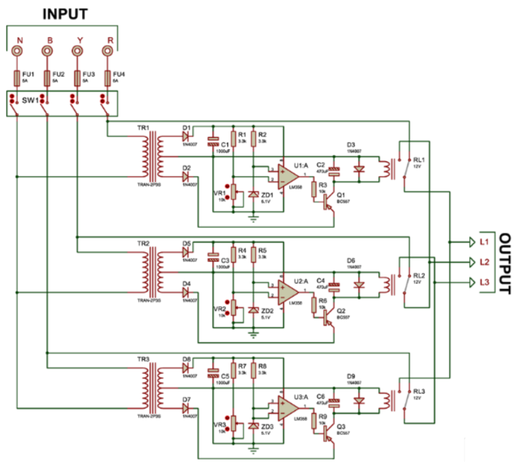

Figure 2: Automatic Phase Changeover Circuit Schematics (See appendix A for detailed diagram)

1. Fuse – Protection
2. Switch – Control
3. Transformer – Conversion
4. Diode (1N4007) – Rectification
5. Capacitor (1000µF, 470µF) – Filtering
6. Resistor (3.3kΩ, 10kΩ) – Limiting
7. Potentiometer (10kΩ) – Adjustment
8. Zener Diode (5.1V) – Regulation
9. LM358 Op-Amp – Comparison
10. BC557 Transistor – Switching
11. Relay (12V) – Automation

V. RESULTS

The automatic phase changeover circuit was evaluated under seven test conditions to verify its ability to maintain power supply during phase failure. The following table shows the seven test conditions:

Test No.	R Phase Input (V AC)	Y Phase Input (V AC)	B Phase Input (V AC)	Comparator Output	Relay ON	Active Phase to Load	Load Status (ON/OFF)	Remarks
1	230	230	230	High (All)	None	R (default priority)	ON	Normal all phases OK
2	180	230	230	R=Low, Y & B=High	RL2	Y	ON	R voltage low
3	180	180	230	R, Y = Low, B = High	RL3	B	ON	Only B OK
4	180	180	180	All Low	RL3 (fallback)	B (last priority)	ON	Weak fallback
5	230	180	180	R = High	None	R	ON	Priority phase R available
6	0	0	230	Only B=High	RL3	B	ON	All else failed
7	0	0	0	All Low	ALL ON	Short risk (bad config)	OFF	Should avoid — logic conflict

Table 1: Test Cases for APCC (See appendix B for detailed table)

During normal operation (Test 1-3) the circuit correctly preferred phase R when every phase was healthy (230V) and automatically transferred load to phases Y (Test 2) and B (Test 3) when R/Y phase voltages dropped to the 180V threshold. Test 6 confirmed fault tolerance, with the load transferring to phase B after R/Y failure, successfully maintaining power delivery by switching to phase B (230V) after complete failure of phases R and Y (0V). However, during Test 7, a significant design limitation was identified. When all the three phases simultaneously failed (i.e. 0V) the control logic generated conflicting relay activation signals, creating a potential short-circuit condition that forced the system to completely shut down.
Therefore:

1. The voltage threshold detection (180V) triggered phase switching as it was to be designed.
2. The R→Y→B priority hierarchy functioned correctly during partial failures
3. A system lockout condition occurred when all phases failed.

The following bar graph shows phase voltage characteristics and load transfer behavior across different test conditions in Table 1:

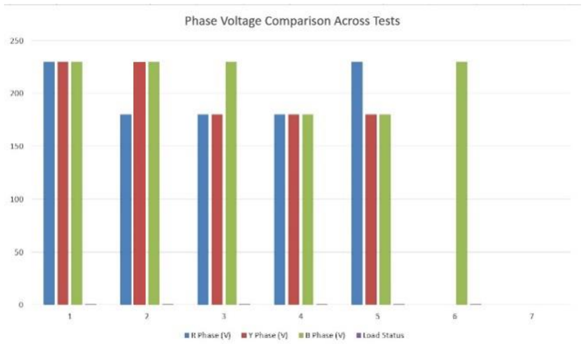

Figure 3: Phase-Voltage Comparison Graph

It compares the voltage levels of R, Y and B phases across the seven different test cases. Each group of bars represents a test condition, and the individual bars show the input voltage for each phase. The chart helps to identify which phase is active at any given test. Plus, it shows voltage drops and failures in specific phases. For example, in Test 2, R phase voltage drops, so the system switches to Y phase. In Test 7, all phases drop, indicating a failure condition. This visualization makes it easier to understand the phase monitoring and the system's behavior at different conditions.

VI. FUTURE RECOMMENDATIONS:

A. *Component Upgradation:*

- For increased reliability, use stronger or higher-quality relays.
- Looking into using solid-state relays for faster switching.
- Using better precision op-amp.
- Using more efficient transformers and power supplies.

B. *Circuit Simplification / Optimization:*

- Exploring different circuit designs to reduce the components count.
- Investigating the use of Integrated Circuits (ICs) that combines multiple functions.
- Use a dedicated phase-detection IC to replace discrete op-amps and Zener diodes.

C. *Microcontroller Integration:*

- Using microcontrollers for more intelligent control.
- Suggesting the use of digital signal processing (DSP) to examine phase voltages and detect problems.

D. *Improved Monitoring and Diagnostics:*

- Adding LED indicators or an LCD display to display the status of phase and relay.
- Monitoring data for analysis and troubleshooting.

E. *Scalability and Adaptability:*

- Designing the circuit to be easily accessible for different voltage or current levels.
- Making the circuit adaptable to different phase configuration or load types.

VII. CONCLUSION

The Automatic Phase Changer is a circuit that changes the phase automatically. Thus, it can find its application in households, hospitals, and even in industries for emergency loads. When the energy is restored, the manual changeover switch must be done manually, be it a change from generator to public supply or vice versa. The importance attached to cases of operation in hospitals and airports to save life from generator as fast as possible makes it important for the design and construction of an automatic changeover switch which would solve the problems of the manpower. It also reduces phase-switching delays to less than 50ms, critical for life-support equipment. The electronic control monitors the incoming public supply voltage and detects when the voltage drops below a level that electrical gadgets can function depending upon utility. In a three-phase application, if low voltage is available in any one phase and if we want our equipment to work on normal voltage, it will solve our problem. Therefore, it was designed to automatically select any one phase without affecting the load.

VIII.REFERENCES

1. Google Scholars (Research Paper)
2. Website:
   https://bestengineeringprojects.com/automatic-phase-changeover-circuit-for-continuous-power-supply/

   https://www.seahipublications.org/journal/engineering-mathematics-technology/ijisetr-vol-12-issue-3/?utm_source=chatgpt.com

APPENDICES

A.

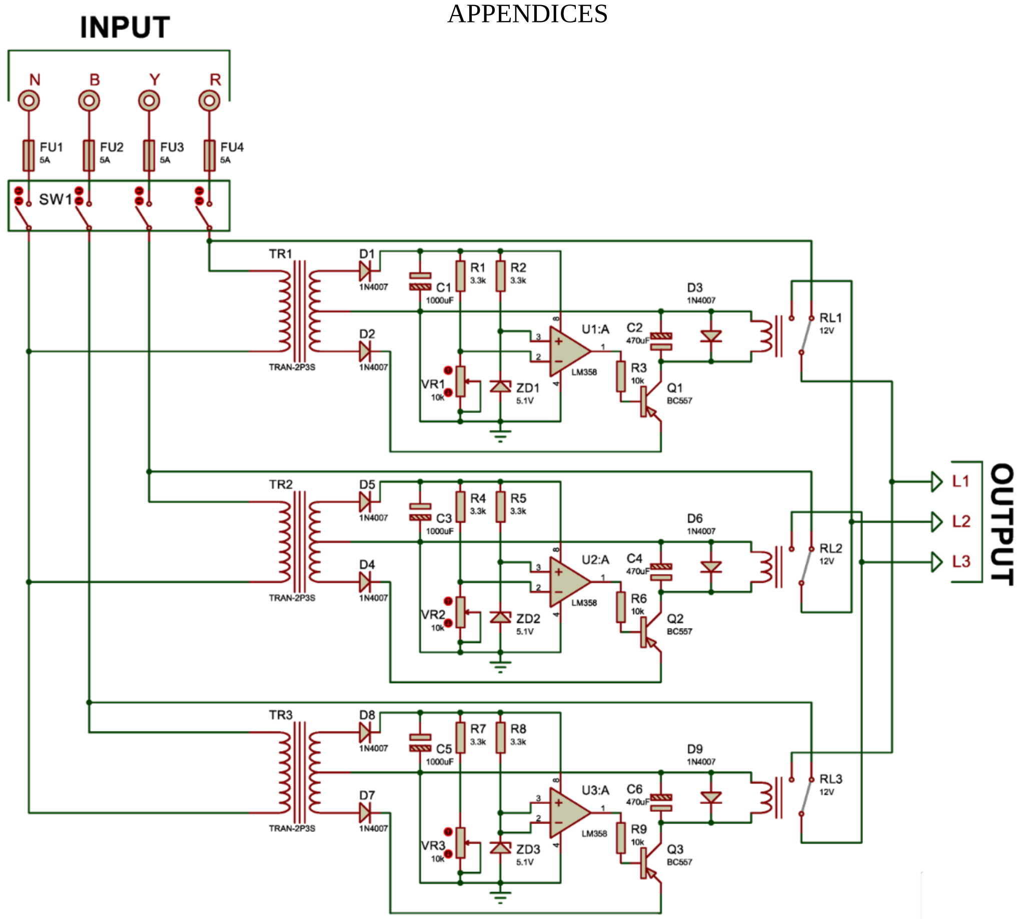

Figure 2: Automatic Phase Changeover Circuit Schematics (Created and Simulated Using Proteus 8 Professional)

B.

Test No.	R Phase Input (V AC)	Y Phase Input (V AC)	B Phase Input (V AC)	Comparator Output	Relay ON	Active Phase to Load	Load Status (ON/OFF)	Remarks
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