

Automatic Multiphase Intelligent Switching System Using Microcontroller with Mobile App Interface

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Abstract: The design and implementation of an automatic multiphase intelligent switching system for a three-phase power supply are the subjects of this study. It offers a way to automatically switch between phases in the event of a power outage in the current phase. The system can be remotely monitored via a Bluetooth interface that connects to a mobile application that functions as a display panel. It also automatically detects the restoration of any or all of the mains' three phases and compares voltages against under voltage and overvoltage before changing over. Microcontrollers, HC05, transformers, transistors, and relay switches were used to do it.

Keywords: Microcontroller, Bluetooth, Mobile App, Multiphase, and Changeover Switch.

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I. INTRODUCTION

Power instability and phase failure pose significant threats to Nigeria's economic development as an emerging nation. The key factors contributing to unreliable and inconsistent electricity supply include issues such as phase failure, phase imbalance, and earth faults (Agbetuyi, 2011). Many households and businesses, which typically need a single-phase power supply, are often equipped with two or three-phase systems. This configuration allows for manual switching between phases in case of fluctuations or outages in a specific phase.

The objective of this setup is to ensure that appliances remain powered; however, due to its manual operation, it carries inherent risks. Transitioning between phases can be fraught with danger. To tackle these challenges, an automatic multiphase intelligent switching system would be implemented. This system will activate and supply power from a single phase if any of the three-phase sources experiences an interruption.

The distinctive feature of this design lies in its capability to assess voltages in relation to both under voltage and overvoltage, which can additionally be monitored remotely via a mobile phone application.

➤ General Objectives

The primary goal of this research is to create and simulate an effective and dependable automatic multiphase

switching system that monitors and compares voltage levels, all accessible through a mobile app.

II. LITERATURE REVIEW

In a study conducted by Emily B. (2011), it was noted that three-phase power was first implemented at an electric convention in Germany in 1891. Despite the fact that many homes are still wired for single-phase power, three-phase distribution has become the predominant method of electrical supply globally.

In Sudan, Ahmed et al. (2014) developed a monitoring system for distribution transformers utilizing GSM technology.

Joseph G.C. (2014) introduced a phase selector system that operates via RF remote control.

Oduobuk et al. (2014) carried out the design and implementation of an automatic three-phase changer using an LM324 quad integrated circuit. In 2017, Ofualagba designed and simulated an Automatic Phase Selector and Changeover Switch for three-phase power supplies. This system incorporated one of four analog multiplexers (CD4052), an analog to digital converter (ADC0804), an AT89C51 microcontroller, and relay switches, allowing it to switch to generator supply in the event of a complete failure of all three AC mains phases.

Iwu (2015) developed an Automatic Three Phase Power System Selector that automatically switches to an alternative phase with current during instances of power loss or very low current in the phase connected to the load, without the overall power being turned off. Lalit Patil (2016) designed an automatic phase selector using an 89C52 microcontroller. This system necessitates the installation of appropriately rated fuses in the R, Y, and B input lines across three phases in cases of low supply voltage. It efficiently moves to the next phase as soon as the suitable voltage is restored.

- A voltage detection unit with three phases
- A microcontroller (voltage comparator) serving as the system's central processing unit or "brain"
- A relay, which is an electromechanical switching device
- An LCD screen
- A power source
- Bluetooth connectivity

➤ *An Automated Multi-Phase Intelligent Changeover System's Block Diagram.*

III. METHODOLOGY

As illustrated by the block diagram, the system comprises several functional components. These are:

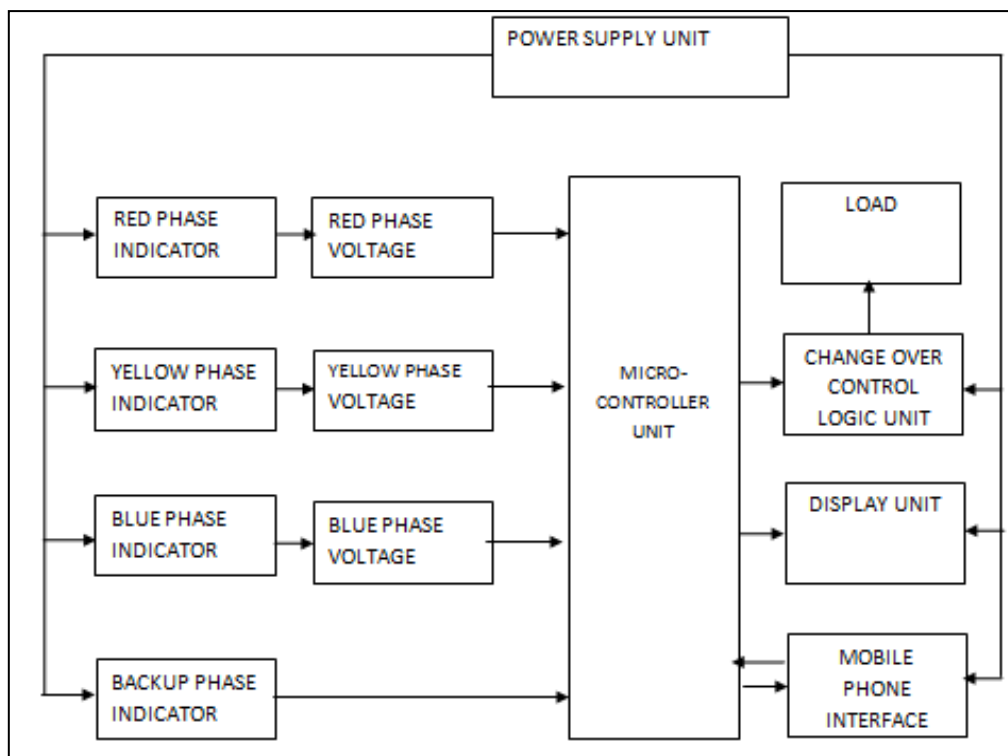


Fig 1 Block Diagram

➤ *Circuit Operation*

The Automatic Phase Selector and Changeover circuit consists of three transformers (T1, T2, and T3), each connected to a different phase of the public utility supply. These transformers reduce the phase voltage from 240V AC to 12V AC. This 12V AC voltage is then transformed into a pulsating 9V DC voltage through a full wave bridge rectifier circuit. An electrolytic capacitor is employed to smooth the pulsating 9V DC into a stable 9V DC. Subsequently, a voltage divider network reduces the 9V DC to a maximum of 1.17V DC. This lowered voltage is sent to the Arduino Microcontroller Unit for additional processing and evaluation.

The ROM of the microcontroller unit is programmed with logic that analyzes all of the DC voltage inputs and determines which phase is the most stable, safe, and available. To ensure the load is powered without any signs of

a power interruption, the processed signal is conveyed to the appropriate pin, which subsequently activates or rotates the connected phase.

➤ *Mode of Operation*

The mode of operation of the automatic multiphase intelligent switching system basically explained in the two modes, Normal and shift mode;

➤ *Normal Mode:*

Only one output will be at logic "1," even though the truth table expression may have any number of available phases (and at any given time, a number of the available phases may be at logic "1"). This implies that just a specific phase has the highest priority and needs to be completed first. "X" in the truth table denotes the absence of a phase, meaning the input may be at logic 0.

Table 1 The Truth Table of Normal Mode Operation

logic input			control logic output			
R	Y	B	R	Y	B	
1	X	X	1	0	0	R PHASE
X	1	X	0	1	0	Y PHASE
X	X	1	0	0	1	B PHASE
X	X	X	0	0	0	

➤ Circuit Diagram of Multi Phase Switching System

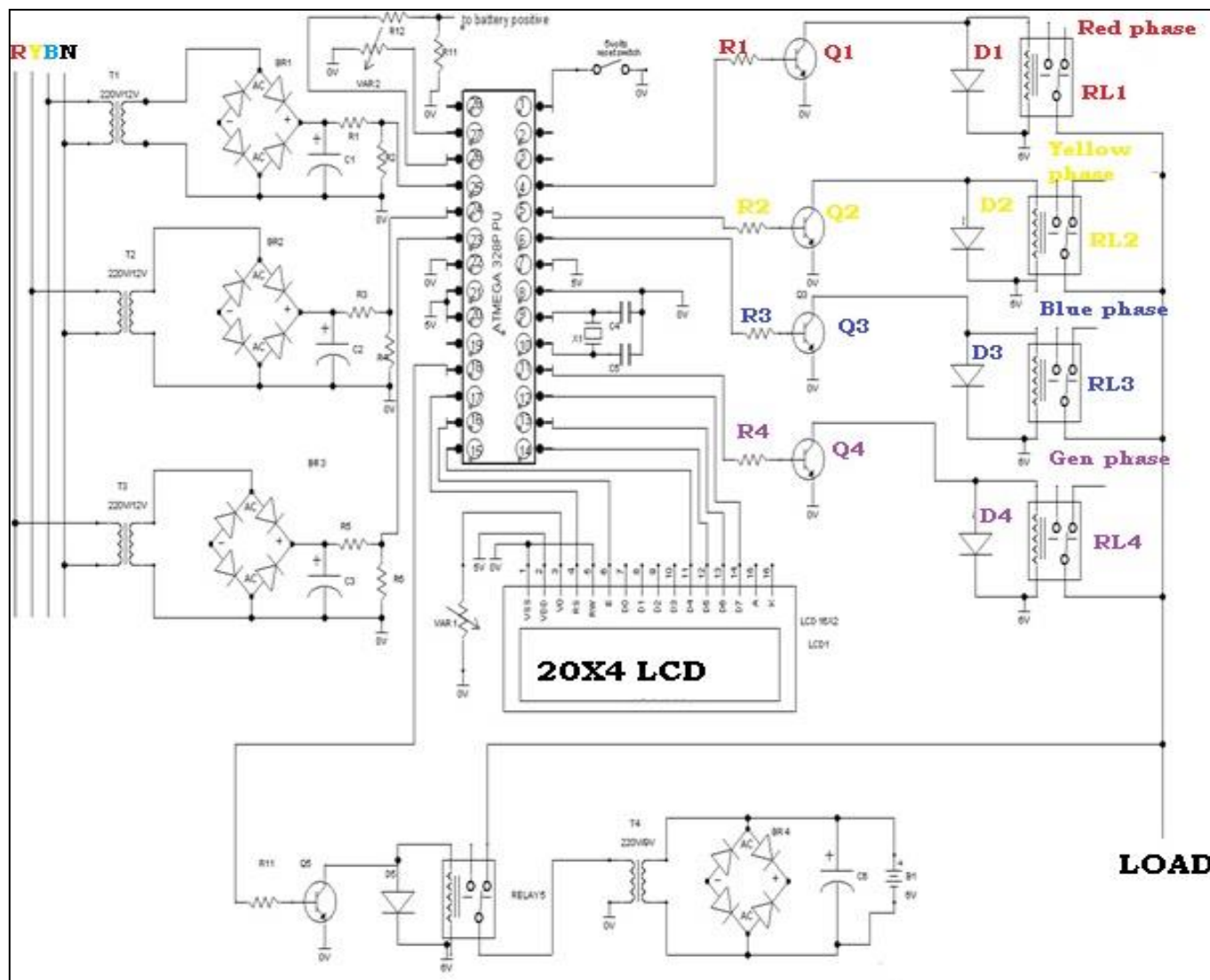


Fig 2 A Circuit Diagram of Multi-Phase Switching System.

IV. RESULTS AND CALCULATIONS

Voltage of the transformer's secondary winding VS = 9V

➤ The Transformer Specifications

Based on this project a step down transformer of 220Vac to 9Vac was used.

Transformer primary current (primary winding current) IP=200mA
 Transformer secondary current (secondary winding current) IS=? Using the transformer equation

Input voltage of the transformer (primary winding) VP = 220Vac

$$\frac{\text{voltage in the primary winding (VP)}}{\text{voltage in the Secondary winding (VS)}} = \frac{\text{current in secondary winding (IS)}}{\text{current in Primary winding (IP)}}$$

$$V_p = 220V$$

$$V_s = 9V$$

$$I_p = 200mA = 0.2A$$

$$I_s = ?$$

Therefore,

$$I_s = \frac{V_p \times I_p}{V_s} = \frac{220 \times 0.2}{9} = \frac{44}{9} = 4.88A$$

Consequently, the transformer's secondary winding current is 4.88A.

➤ *Rectifier Circuit*

Four IN4001 diodes are used in a bridge circuit that makes up the rectifier circuit. The bridge circuit transforms alternating electricity into direct current using a full wave rectifier. Because the bridge circuit would produce a distinct reference voltage from the AC reference voltage, it was utilized.

➤ *Peak Inverse Voltage*

According to Metha V.K. and Metha R. (2008), peak inverse voltage is twice the maximum voltage across the half wave.

That is,

$$PIV = 2V_{max} = 2V_s$$

$$\text{Therefore, } PIV = 2 \times 9 = 18V$$

The mean Load current and power dissipated in each of the diode having load resistance as 10k and diode resistance as negligible.

$$I_{dc} = \frac{2IM}{\pi}$$

$$I_m = \frac{V_m}{r_f + R_L}$$

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

$$V_{max} = 220 \sqrt{2} = 311.1V$$

At every half circle 2 diode conducts

Therefore,

$$R_f = 2R_f$$

$$I_m = \frac{V_m}{2r_f + R_L}$$

$$I_m = \frac{311.1}{2 + 1000}$$

$$I_m = \frac{311.1}{2 + 1000} = 0.31$$

$$I_{dc} = \frac{2I_m}{\pi}$$

$$I_{dc} = \frac{2 \times 0.31}{3.142}$$

$$I_{dc} = \frac{0.62}{3.142} = 0.19A$$

Power Dissipated In Each Diode

$$I^2 \times r_f$$

R_f which is diode resistance.

Current (I) which is the Irms is unknown

Therefore,

$$I_{rms} = \frac{I_m}{\pi}$$

$$I_{rms} = \frac{0.31}{3.142} = 0.098$$

Therefore,

$$\text{Power} = I_{rms}^2 \times r_f = 0.098^2 \times 1 = 0.009 \text{ Watt}$$

➤ *Voltage Divider Network*

For the voltage divider network applies to the analog input of the microcontroller is given as:

$$V_{in} = 13V, R_1 = 10K, R_2 = 1K$$

$$V_{out} = V_{in} \left(\frac{R_2}{R_1 + R_2} \right)$$

$$V_{out} = 13 \left(\frac{1000}{10000 + 1000} \right)$$

$$V_{out} = 13 \left(\frac{1000}{11000} \right)$$

$$V_{out} = 13(0.09) = 1.17V$$

➤ *Smoothing or Filter Circuit*

It will be necessary to use a low pass filter that maintains the rectified voltage's dc component. The signal waveform that needs to be rectified is 50 Hz at 220Vrms based on this design.

Thus, F ripple = 2x50 = 100Hz is the ripple frequency.

V. CONCLUSION

A residential building's electrical power system can be efficiently monitored and controlled by the installed system

without interfering with the supply when switching between phases. A Bluetooth interface on a smartphone app allows users to view the available phase.

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