VOL. 04 NO. 5,
MAY, 2024
E-ISSN 3027-1339
P-ISSN 3026-8257



African Scholar Publications & Research International
www.africanscholarpub.com

Journal of Systematic, Evaluation and Diversity Engr. (JSEDE)

DESIGN AND ANALYSIS OF AN AUTOMATIC SELECTION SYSTEM FOR MULTIPLE ELECTRICAL POWER SOURCES

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Abstract

The requirement for electric power in our daily lives has increased due to the growing usage of technology in everyday tasks worldwide. Thus, the requirement for continuous electricity becomes critical to the efficient operation of contemporary technologies. Continuous blackouts in Nigeria have caused systemic breakdowns and occasionally fatalities, requiring the usage of several separate, varying-cost power sources for residences, workplaces, and industrial facilities. The design and implementation of a microcontroller-based multiple source power selectors with a priority selector are presented in this work. Priority selection allows sources to be chosen for use according to their uninterruptibility or cost. When choosing based solely on cost, mains electricity is chosen before generators, and when neither is available, generators are chosen last.. The higher-quality source is chosen for use when uninterruptible power (UP) is given priority. Each of the three sources is rectified, sampled, and stepped down using a transformer. The ATmega328 microprocessor is then programmed to select the best output based on availability or cost. The system was simulated using the Proteus simulation environment. The simulation's findings indicate that, regardless of the performance scenario, the source that feeds the output depends on the priority mode that was chosen. For houses where power costs are the primary consideration, this system can be operated in economy mode; however, in hospitals, where availability is more important, it is

advisable to utilize the UP-priority option. In conclusion, if consumers connect their electronic devices to the device, the likelihood of a total power outage in the event of a power outage at any specific source is decreased. By using the least expensive source in economy mode, it also decreased the cost of powering the load or house. To facilitate more study and enhance system performance, it is advised that a hardware model of the concept be created and tested.

Keywords: Electric Power, Power Selectors, Uninterruptible Power, Power Outages, Microcontroller, Transformer, Proteus Simulation.

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Introduction

Nigeria and the majority of underdeveloped nations worldwide have extremely erratic power supplies. In many regions of the world, consumers and operating equipment are negatively impacted by the unstable nature of the power supply (Bishe, 2017). Their economic progress has been seriously threatened by power instability and phase failure (Kyereh, 2017). This implies that development cannot occur in areas with unstable power supplies. However, because of one or more technical issues with power generation, transmission, or distribution, the majority of businesses, commercial, industrial, and even domestic establishments rely on the unstable public power supply (Adedokun, 2010). Most businesses, whether they are residential or commercial, today use multiple power sources, such as solar, generators, and mains (Bathi, 2021). Since all three sources are available, anyone can be chosen to be used. Uninterruptible power is required for ATMs, surgeries, Zoom meetings, online lectures, and other applications. However, for light amusement, such as watching TV or listening to music, the cheapest source will do, even if it is inconsistent. Previously, the switchover was done manually, which meant that it would take a lot of time and effort to complete (Lawal, 2017). An automatic source switching system with a priority selection option is necessary since a delay

in the process of changing the source
could seriously harm products and
machinery, possibly even resulting in the loss of life in surgical circumstances (Oduobuk, 2021). A user may have several power sources in his house, such as solar power, a generator set, or "NEPA" power. Depending on the user-specified option (economy or uninterrupted), this study work identifies all three of these power sources and automatically chooses the best one (Ofualagba, 2017). This is advantageous since it eliminates the need to physically reach for the changeover switches. The goals of this research project are to interface different electrical components to a controller, design and simulate a circuit that automatically chooses electricity from a variety of power sources in a house, program the controller in C++, and use MATLAB to analyze the system.

LITERATURE REVIEW

According to (Kyereh, 2017), one of the utility company's main goals is to be able to offer consistent power to client loads. As technology has advanced, numerous ideas have been put into practice to create various methods for automatically achieving healthy phase selection during faults. Thus, employing logic gates and power electronic devices, a real-time automatic phase selector was built (Bhise, 2017). Therefore, it is advised to scale up and minimize other electrical circuits and digital circuits in order to enhance design and development. According to (Adedokun, 2010), the automatic phase changer was constructed using a variety of electronic parts, such as relays, fuses, operational amplifiers, diodes, resistors, capacitors, and Zener diodes (Khairul, 2011).

The test's results demonstrated that the system activates the load whenever it detects a greater voltage across at least one of the three inputs. It was not intended for the system to manage high power loads, but rather modest power loads. Furthermore, in this investigation, system durability, compatibility, and reliability were not taken into account. The automatic three-phase power system selector, according to (Shokoya, 2019), was built and intended to automatically switch to the other phase with current in the event of a power outage or abnormally low current in the phase to which the load is attached without the power being off.

When there is a mains supply outage, the selector connects the load to the other phases and relay switches enable the use of the remaining phases without disturbing or halting

the load. By automatically turning on the phases when necessary, it keeps the load powered continuously. This protects the electronics system against burnout and damage caused by voltage instability, collapse, and persistent outages—all of which are critical in emerging and underdeveloped nations. (Bhise, 2017) noted that although we frequently have three-phase supplies, only one phase is needed to run some technology, such as commercial Internet servers and operating theaters in hospitals.

Relay logic that is used correctly can select an available phase automatically and prevent short circuits between phases. Electrical components like relay switches, undervoltage, overvoltage, and transformers could be used to do this. (Nweke, 2015) noted that there were issues in industrial power systems due to the variance in voltage level per phase in a three phase supply circuit. As a result, a system that only connects the load to live phases that are available must be designed to verify for their availability.

This achievement was made possible using a microprocessor (PIC16F628). (Khairul, 2011) suggested designing and building an automatic phase selection and changeover switch for a three-phase power supply. This would provide for the ability to switch between the AC mains' phases in the event that one fails. In the event that one of the three AC main phases fails, it also switches to a generator. Without any indication of a power interruption, the circuit also detects the return of any or all three mains phases and the changeover (Owojori, 2021).

The project's goal was to enhance the many electromechanical device kinds that have been in use for a while. The AT89C51 microcontroller, relay switches, analogue to digital converter (ADC0804), and one of four analogue multiplexers (CD4052) were used to implement the suggested system (Ihedioha, 2017).

METHODOLOGY

Below are the system specifications and requirements for the project titled "Design and Analysis of an Automatic Selection System for Multiple Electrical Power Sources":

System Specifications:

Power Sources:

- Grid Power: Standard AC power supply from the local utility provider.
- Solar Power: Photovoltaic (PV) panels for renewable energy generation.

- Backup Generator: Diesel or gasoline-powered generator for emergency backup power.

Sensors:

- Voltage Sensors: Measure the voltage levels of each power source.
- Current Sensors: Monitor the current flow from each power source.
- Frequency Sensors: Check the frequency of the supplied power.

Controller:

- Microcontroller or Programmable Logic Controller (PLC): Acts as the central processing unit for the system.
- Decision-Making Algorithm: Determines the selection of the power source based on predefined criteria.
- User Interface: Interface for programming and monitoring system operations.

Switching Mechanism:

- Relays or Solid-State Switches: Enable seamless transition between power sources.
- Safety Mechanisms: Ensure safe switching operations to prevent damage to the system and connected devices.

User Interface:

- Display Panel: Shows the current power source selection, system status, and any alerts or notifications.
- Control Interface: Allows users to interact with the system, configure settings, and manually override automatic selections if necessary.

System Requirements:

Automatic Power Source Selection:

- The system should automatically select the most appropriate power source based on predefined criteria such as availability, cost, environmental factors, and user preferences.

Emergency Handling:

- The system should have provisions for automatically switching to the backup generator in the event of grid power failure or other emergencies.

User-Friendly Interface:

Offer a user-friendly interface that makes it simple to configure, monitor, and troubleshoot the system. With an emphasis on effectiveness, dependability, safety, and user-friendliness, these system criteria and standards offer a framework for developing and evaluating an Automatic Selection System for Multiple Electrical Power Sources. The block diagrams shown in Figures 1 and 2 were used as a guide to help determine the values of the various components when this system was put into practice.

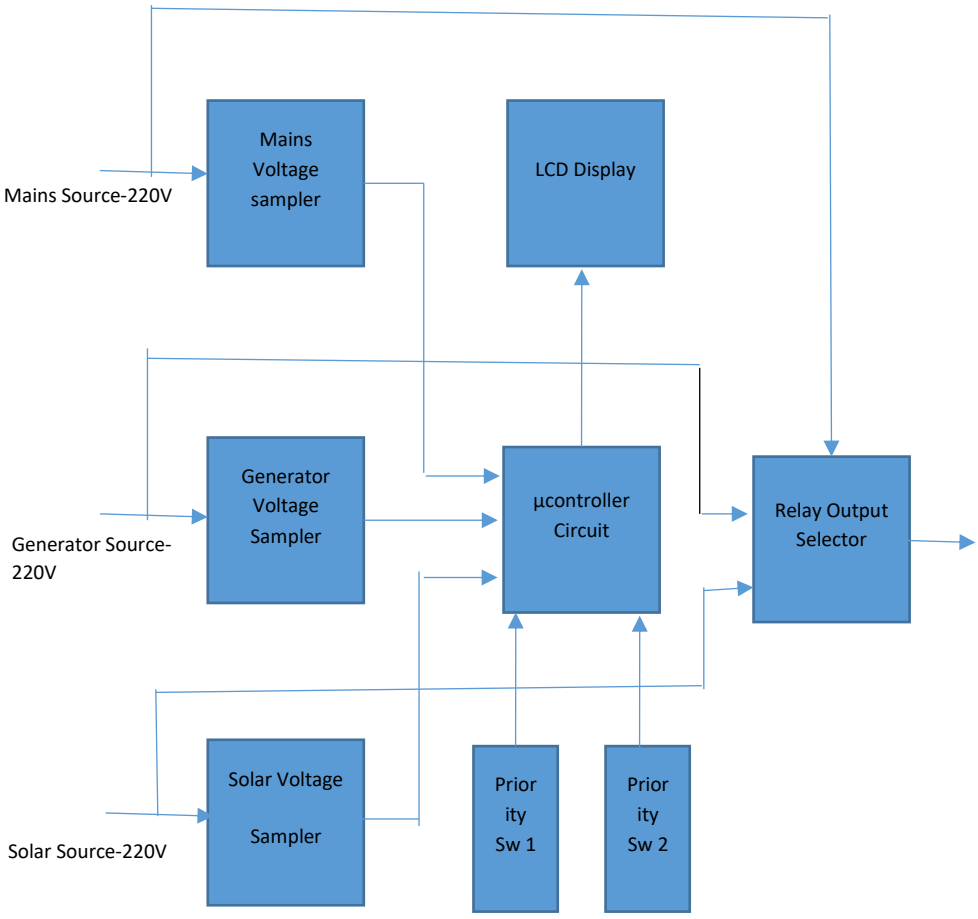


Figure 1: *Block diagram of the multiple sources Power Selector*

Voltage Sampler Design

Each of the source's voltage is stepped down via a 220V/12V stepped down transformer, the output of which is rectified and filtered to be used by the microcontroller as sample voltage. The connection for sampling is shown in figure 2.0.

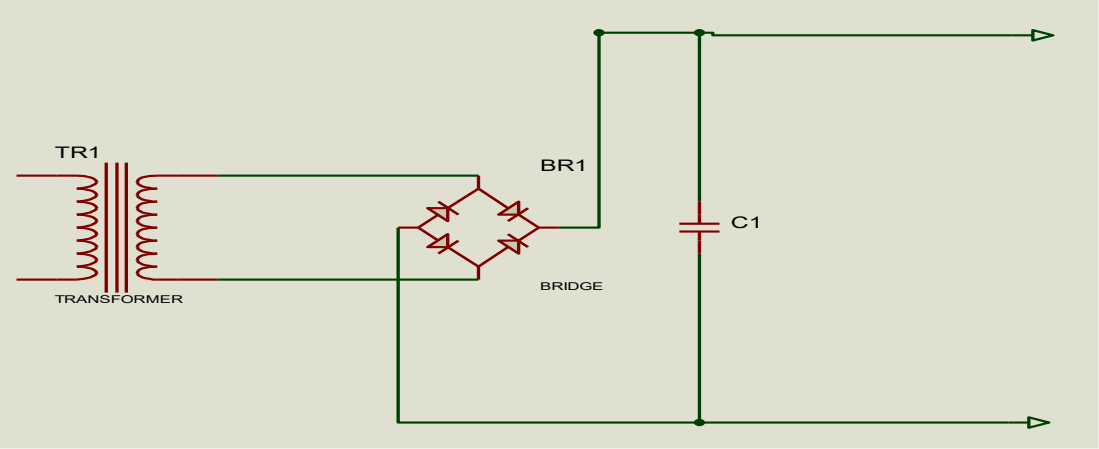


Fig. 2.0: *Circuit Diagram of Sensing Unit*

The voltage sampler or source is designed with the following specifications: Output voltage 12V ± 5 % at 0.5A with maximum ripple voltage of 2V peak-peak

Calculations

Choose rectifier:

A bridge rectifier made from four diodes all 1N4001 is chosen, data sheet says it has a forward voltage drop of 1.0V at 1A

Needed transformer voltage:

i.e Vrms * 1.414 must be > 12 + 1.0 + (Vripple = 2V) = 15.0v

With Vrms = 15.0/1.414

= 10.6V

Choose transformer:

The nearest suitable transformer is 220V at 1.0A

Transformer power = I*V

P=220V*1.0A

=220W

Choose capacitor:

to determine the capacitor size

Vpk-pk ripple= Iload / fC or C = Iload / f * Vpk-pk ripple

C = 0.5 / 100 * 2

= 0.5/ 200

= 0.00025f

= 250 µf with a minimum voltage rating of 15V + 20% safety margin

= 18.0V

The Circuit Diagram

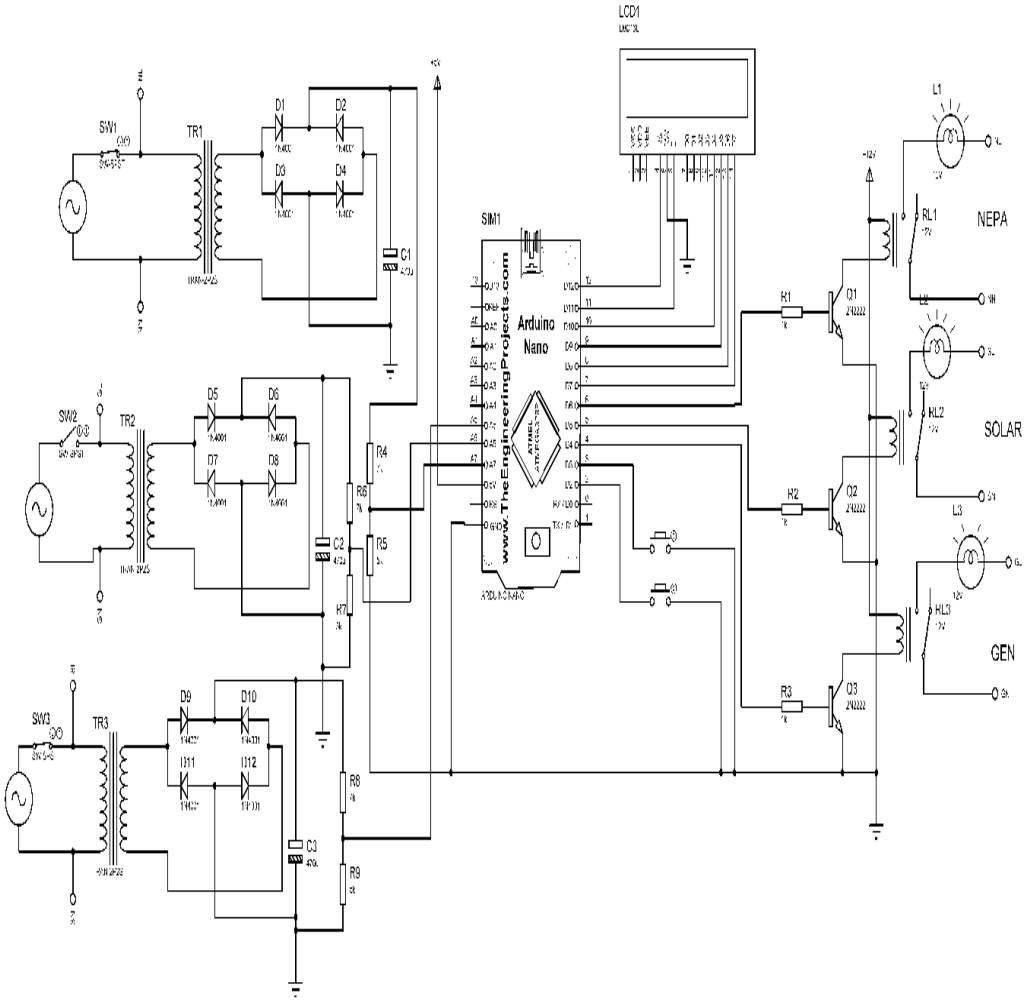


Figure 3.0: *Circuit diagram of the multiple power source selectors*

Microcontroller/Programming

The microcontroller employed in this design is an Arduino Nano microcontroller. This controller comprises of an ATMEGA328p chip. The Arduino program was written in

C++ language, compiled by the Arduino IDE windows program and uploaded into the chip via USB connection.

The flow chart for the logic flow in the program is given in figure 4.0

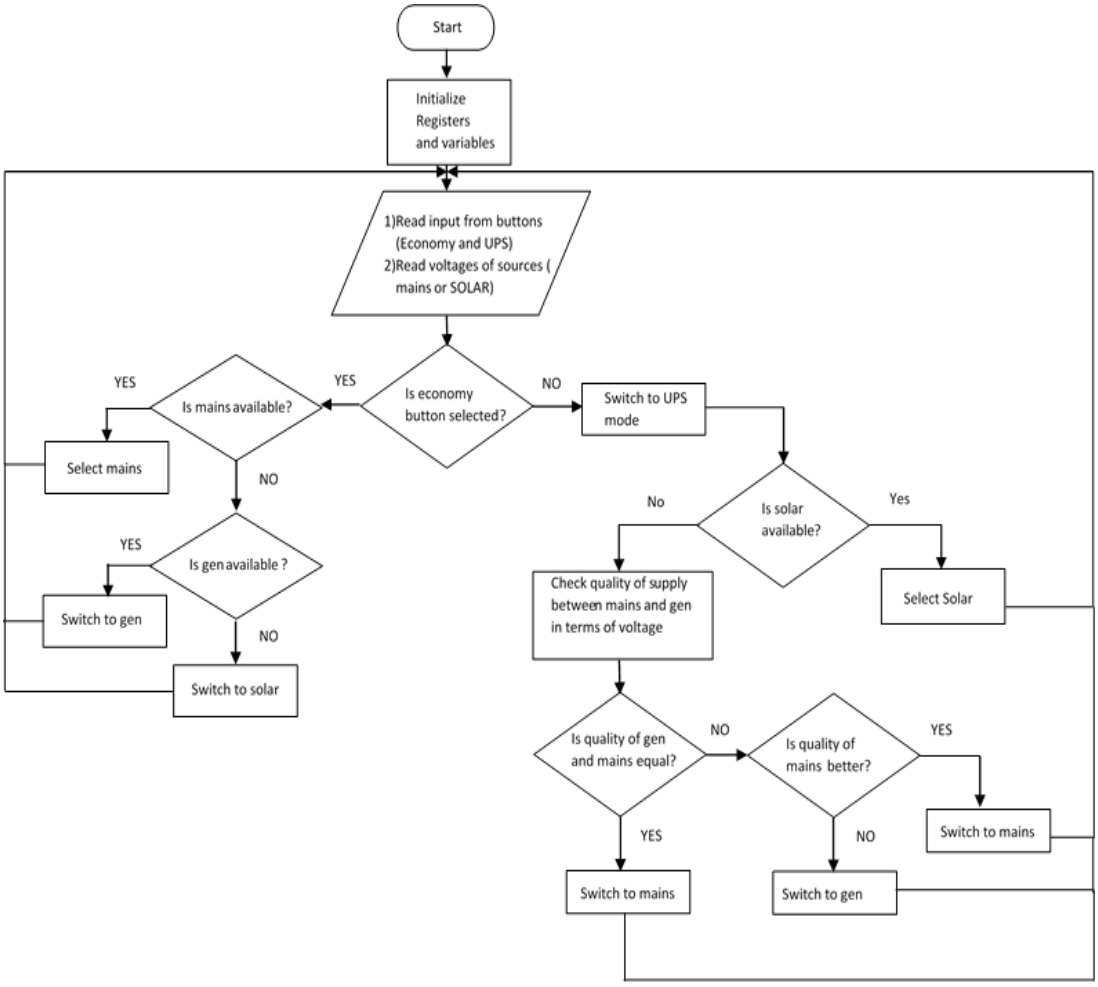


Figure 4.0: *flow chart for the logic flow in the program*

RESULTS

It is expected that at the end of this research work the following results (table 1.0 and table 2.0) will be realized, depending on the choice of the user.

Table 1.0: Economy Priority Selected

S/N	Mains Source	Generator Source	Solar Source	Selected Source
1	On	On	On	Mains
2	On	On	Off	Mains

3	On	Off	Off	Mains
4	Off	On	On	Generator
5	Off	On	Off	Generator
6	Off	Off	On	Solar
7	On	Off	On	Mains

Table 2.0: UPS priority selected

S/N	Mains Source	Generator Source	Solar Source	Output
1	On	On	On	Solar
2	On	On	Off	Generator
3	On	Off	Off	Mains
4	Off	On	On	Solar
5	Off	On	Off	Generator
6	Off	Off	On	Solar
7	On	Off	On	Solar

Source Code

/*Certainly! Below is the Arduino program modified to include two modes of operation: Economy mode and Reliable mode. The user can switch between these modes using a button connected to a specific pin.
*/

```
// Define the digital input pins
const int inputPin1 = 2;
const int inputPin2 = 3;
const int inputPin3 = 4;

// Define the digital output pins
const int outputPin1 = 5;
const int outputPin2 = 6;
const int outputPin3 = 7;

// Define the mode selection button pin
const int modeButtonPin = 8;
```

```
int mode = 1; // 1 for Economy mode, 2 for Reliable mode

void setup() {
  // Set the digital input pins as inputs
  pinMode(inputPin1, INPUT);
  pinMode(inputPin2, INPUT);
  pinMode(inputPin3, INPUT);

  // Set the digital output pins as outputs
  pinMode(outputPin1, OUTPUT);
  pinMode(outputPin2, OUTPUT);
  pinMode(outputPin3, OUTPUT);

  // Set the mode selection button pin as input
  pinMode(modeButtonPin, INPUT_PULLUP);

  // Initialize serial communication
  Serial.begin(9600);
}

void loop() {
  // Read the state of the mode selection button
  if (digitalRead(modeButtonPin) == LOW) {
    // Change mode when button is pressed
    mode = (mode == 1) ? 2 : 1;
    delay(500); // Debounce delay
  }

  // Read the state of each digital input
  int state1 = digitalRead(inputPin1);
  int state2 = digitalRead(inputPin2);
  int state3 = digitalRead(inputPin3);

  // Print the state of each input (optional)
```

```
  Serial.print("Input 1: ");
  Serial.print(state1);
  Serial.print(" | Input 2: ");
  Serial.print(state2);
  Serial.print(" | Input 3: ");
  Serial.println(state3);

  // Choose the mode of operation
  if (mode == 1) { // Economy mode
    digitalWrite(outputPin1, ((state1 == HIGH && state2 == LOW && state3 == LOW) || (state1 == HIGH && state2 == LOW && state3 == HIGH) ) ? HIGH : LOW);
    digitalWrite(outputPin2, (state2 == HIGH || (state2 == HIGH && state3 == HIGH) || (state1 == HIGH && state2 == HIGH) || (state1 == HIGH && state2 == HIGH && state3 == HIGH) ) ? HIGH : LOW);
    digitalWrite(outputPin3, (state1 == LOW && state2 == LOW && state3 == HIGH) ? HIGH : LOW);
  } else { // Reliable mode
    digitalWrite(outputPin1, ((state1 == HIGH && state2 == LOW && state3 == LOW)) ? HIGH : LOW);
    digitalWrite(outputPin2, ((state3 == LOW && state2 == HIGH && state1 == LOW) || (state1 == LOW && state2 == HIGH && state3 == HIGH) || (state1 == HIGH && state2 == LOW && state3 == HIGH) || (state1 == HIGH && state2 == HIGH && state3 == HIGH)) ? HIGH : LOW);
    digitalWrite(outputPin3, ((state1 == LOW && state2 == LOW && state3 == HIGH) || (state1 == HIGH && state3 == HIGH)) ? HIGH : LOW);
  }

  // Add a delay to avoid rapid toggling (adjust as needed)
  delay(100);
}
```

/*In this code, the mode selection button is connected to pin 8. When the button is pressed, it toggles between Economy mode and Reliable mode. Depending on the selected mode, the outputs are set according to the specified conditions. Adjust pin

numbers and other parameters based on your specific hardware setup.
*/

CONCLUSION

To provide a continuous power supply to vital infrastructure, an automatic input selection for a three-phase power system was designed, simulated, and built. An output equal to the input is created anytime there is voltage input in any of the three phases or in a combination of the phases, according to the findings of the automated system's performance test. The design calls for an automatic execution of this process.

ACKNOWLEDGEMENT

This research work is an embodiment of trust and assistance received from the tertiary education trust fund (TETFund). For without this sponsorship, it will be difficult to carry on with this study. We therefore use this opportunity to express our joy and happiness for benefiting from this support.

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