

Development of a Cost-Effective Automatic Power Transfer Switch for Backup Energy Systems

Nikita Namdev Mardhekar^{1*}, Swapnali P. God²

Abstract

This study offers a practical solution to the frequent power outages in places like Nigeria, where having backup power sources, such as inverters, is crucial. To make switching between the main power supply and backup power easier, the authors created a simple but effective transfer switch. The design uses important components like an electromechanical relay, a contactor, a voltage monitoring relay, and delay timer relays to ensure smooth switching between power sources. The system was first tested on a breadboard before being assembled onto a printed circuit board (PCB) for the final version. The transfer switch has 66.3% efficiency, which is typical for this kind of a power system, and can handle a maximum load of 10 A. This affordable system improves the reliability of backup power for both emergencies and everyday use. In the future, the authors suggest using more efficient power supplies to reduce energy loss and improve performance.

Keywords: Power system, backup power source, inverter, transfer switch, automatic switching, relays, circuit testing, PCB, power supply unit, voltage comparator, switching system

INTRODUCTION

The capacity to switch between the primary power source and the backup source quickly and effectively is one of the most important components of keeping a reliable backup power system. This procedure must be automated to prevent any power supply delays or interruptions, especially during emergencies or periods of high demand. One crucial element in this respect is the automated transfer switch (ATS), which guarantees a smooth transition between the primary and secondary power sources, such as the main grid and a backup generator or inverter.

An automatic transfer switch (ATS) is a device that automatically transfers a power supply from its primary source to a backup source when it senses a failure or outage in the primary source. An automatic transfer switch (ATS) is a self-acting, intelligent power switching device governed by dedicated control logic. The automatic transfer switch, which is a switchgear control system, provides a functional system that offers an automatic switching of power supply between a primary source and secondary source is generator [1].

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Effectively switching from the primary power source to the backup source is one of the most important components of keeping a reliable backup power system. Especially in emergency situations or periods of heavy demand, this procedure must be automated to prevent any delays or disruptions in the power supply. An important part of this process is the automated transfer switch (ATS), which makes sure that the main grid and a backup generator or inverter can switch between primary and secondary power sources with ease.

In this study, a straightforward yet efficient automatic transfer switch is designed and implemented as a solution to these problems. Electromechanical relays, contactors, voltage monitoring relays, and delay timer relays are some of the essential parts of the suggested system that cooperate to provide seamless and effective functioning. After being functionally tested on a breadboard, the system was then moved to a printed circuit board (PCB) for real-world application.

The method laboring in designing the automatic transfer switch includes the use of electromechanical relay, contactor, voltage monitoring relay and delay timer relays as main components of the system. An automatic transfer switch is an electrical/electronic switch that senses when the mains or public utility supply is interrupted and automatically starts up the secondary supply if the utility remains unavailable.

According to the study, to minimize energy loss and further maximize performance, the system might be improved by implementing switching power supplies that are more efficient. For areas that experience regular power outages, the automatic transfer switch can be extremely important in offering a more reliable, sustainable, and effective power solution.

PARTS OF ATS

ATS has several parts:

- *Power supply unit:* Provides the necessary power to operate the control panel and ensures consistent voltage levels for proper functioning.
- *Voltage comparator:* Monitors the voltage levels from the main grid and the backup power source (inverter) to determine when a switch between the two is necessary.
- *Switching system:* Utilizes relays to automatically switch between the main grid and the backup power source based on the inputs from the voltage comparator.
- *Control panel housing:* Encases and protects the components of the automatic transfer switch, ensuring safety and durability.
- *Indicator lights:* Provide visual feedback on the status of the power source, indicating whether the system is running on main grid power or backup power.
- *Manual override switch:* Allows manual control of the transfer switch in case of emergencies or maintenance needs.

TECHNOLOGICAL ASPECTS OF ATS

Relays

The primary switching mechanism relies on relays, which are electromechanical switches controlled by an electrical signal. These relays facilitate the automatic transfer between the main grid power and the backup source, such as an inverter.

Breadboard and PCB Design

The circuitry is initially tested and prototyped on a breadboard, allowing for easy adjustments and troubleshooting. Once validated, the design is transferred to a printed circuit board (PCB) for permanent implementation, enhancing durability and reliability.

Power Supply Unit

The control panel includes a power supply unit responsible for providing stable power to the circuitry. In this project, a linear 12 V power supply is utilized, ensuring consistent voltage levels for proper operation.

Voltage Comparator

A voltage comparator circuit is employed to monitor the voltage levels from both the main grid and the backup source. This component compares the voltages and triggers the relay switches to initiate the transfer process when necessary.

Efficiency Considerations

The project evaluates the efficiency of the control panel, with a focus on minimizing energy loss and optimizing performance. Future improvements may explore the use of switching power supplies to enhance efficiency further.

LITERATURE SURVEY

By varying the capacity of the main power circuit, Darmanto and Mahardika developed a system that can regulate power sources of various sizes [2]. This indicates that both small and large power requirements can be met by their design. They deliberately designed the system for a single-phase power supply in their study that has a rating of 2200 VA, 220 V, and 50 Hz, which is common for small companies and houses. Their strategy makes the system dependable and adaptable, enabling it to readily adapt to varying power requirements while preserving steady operation.

Jean-Rostand *et al.* addressed typical issues that solar-powered families encounter, particularly when sunlight is insufficient to provide sufficient electricity [3]. A solution to maintaining power even in the absence of sunlight is offered by their project. The fact that many homes and small businesses choose not to purchase solar systems that can completely fulfill their energy needs is another problem it helps to resolve. It is more dependable during periods of high demand since the system makes sure that additional power can be taken as necessary.

An inexpensive automated transfer switch (ATS) for families and other small power users was created by Hasanah *et al.* [4]. Their method switches between the main electrical supply and a generator using relays, detects the power supply using an optocoupler, and controls the switch with an Arduino-Nano microcontroller. Users can easily monitor and control the power source thanks to the LCD panel that shows crucial information.

The significance of quick switching rates and seamless system operation is emphasized by Wakudkar *et al.* [5]. The system is set up to automatically switch to backup power sources if there are problems with the primary supply. Using an automated transfer switch (ATS), a control system that automatically alternates the power supply between a primary source (usually the grid) and a secondary source (like a generator), is their focus. This minimizes disruptions and guarantees a dependable power supply by switching to the backup source promptly when necessary.

The issue of power outages during energy transmission is the focus of Muneer *et al.* [6]. It is critical to supply the growing demand for electricity by utilizing both conventional fuels and renewable resources like solar and wind. An automatic switch that can switch between various power sources is being developed to aid this. A more dependable and sustainable energy supply is ensured by the system's design, which prioritizes electricity from wind and solar farms before delivering it to customers or the electrical grid.

A clever and reasonably priced way to guarantee a consistent power supply even during blackouts has been devised by God *et al.* [7]. Their method minimizes power flow disruptions and is set up to function well in both emergency scenarios and routine backup requirements.

To ensure that the power shifts smoothly when necessary, their system's essential parts are relays, automatic switching, and a transfer switch. To maintain optimal operation, it also comes with a printed circuit board (PCB) and a circuit testing setup. By ensuring stability, a voltage comparator helps to avoid interruptions in the power supply. All things considered, this method provides a dependable and affordable means of maintaining operations, whether for sudden power outages or regular backup requirements.

By switching to a DC (direct current) system, Hidayat and Wijaya hope to lessen the consumption of conventional energy, with intentions to gradually switch to renewable energy [8]. Their research's primary advantage is that the automatic switch system may be modified to control the energy load,

eventually enabling it to operate solely on renewable energy sources without requiring conventional electricity. To prevent the system from going through the same steps twice, they employed a switch case statement technique. The hybrid system they created prioritizes renewable energy as the primary source and can transition between four different energy sources.

Kabir *et al.* demonstrate the development and deployment of a programmable logic controller (PLC)-based automated transfer switch (ATS) [9]. When a backup power source is required, the transfer switch's principal job is to automatically switch electricity from the main grid. Timing delays are a key component of the ATS system, which helps to maximize equipment performance and avoid pointless transfers. The 7-sec delay they saw in their prototype's switching cycle ensures seamless and effective operation.

Narvios *et al.* have created an IoT-based automatic transfer switch that can switch between two power sources, along with a system to monitor and control it [10]. Their design includes a microcontroller, power supply, voltage and current sensors, wireless modules for communication, a display, and a load. The voltage sensor connected to the main power supply sends data to the microcontroller. Based on this information, the microcontroller sends a signal to the relay module to manage the switch between power sources.

SYSTEM ARCHITECTURE

Figure 1 shows how the *Automatic Transfer Switch (ATS)* works to keep power running smoothly when there is a power cut.

- *Normal power (mains supply)*
 - The major power source for your house or building is typically the electric grid. This power is sent to your equipment and devices (the “load”) by the ATS.
- *Power outage*
 - When the main power goes off, the ATS detects the issue right away. After that, it moves automatically to a backup power source, in this case a generator.
- *Backup power (generator)*
 - The generator activates and begins to provide electricity to keep your machines, appliances, and lights operational throughout the blackout.
- *Power restored*
 - The ATS recognizes when mains power returns and connects everything back to the grid. After then, the generator turns off on its own.

Why It is Useful?

This technology ensures that your vital devices continue to function even in the event of a power outage. You do not have to turn any switches or start the generator by hand, the ATS takes care of it! In settings where continuous electricity is necessary, such as factories, hospitals, or even households, it is frequently utilized.

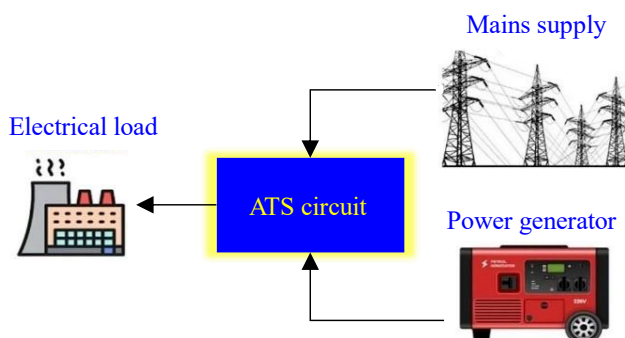


Figure 1 Automatic transfer switch control circuit.

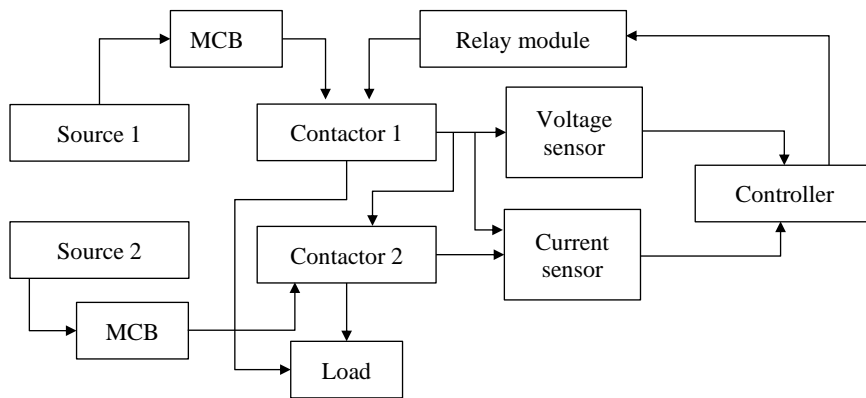


Figure 2. Block diagram of automatic transfer switch control panel.

Block Diagram

The block diagram of automatic transfer switch control panel is shown in Figure 2. When necessary, the system automatically alternates between two sources of electricity to maintain operation. To prevent power outages, a relay swiftly switches on after using sensors to assess the situation.

WORKING

The Automatic Transfer Switch (ATS) system is designed to detect when utility power is restored. Once the ATS detects the presence of utility voltage, it automatically commands the genset (generator) contactor to open, switching the load back to the utility power source. The ATS also ensures the genset shuts down after a specified delay to allow for proper cooling, protecting the generator from potential damage.

The ATS operates in two modes: automatic and manual. In automatic mode, it manages the switch between the utility and genset power sources without intervention. However, since the genset runs on diesel fuel, it requires manual oversight to prevent fuel depletion. Therefore, the ATS is set to operate automatically during weekdays (from 07:30 to 17:00) and manually outside of these hours.

For a typical small power consumer, such as a household with two buildings, the ATS is equipped with several components. These include relays, contactors, a Real-Time Clock (RTC) DS3231 module, an Arduino Nano module, and an optocoupler.

To detect whether utility power is available, the ATS includes a voltage detection circuit. This circuit consists of a diode rectifier (RB156 type), a resistor, a 3 mm LED, and an optocoupler (PC817 type). The diode rectifier converts the AC voltage from the utility source into DC, and the system checks the output voltage from the rectifier to determine whether the utility power is present. This setup ensures reliable detection and smooth switching between power sources.

CONCLUSION

In conclusion, this study presents an innovative approach to developing a smart Automatic Transfer Switch (ATS) to address frequent power outages, particularly in regions like Nigeria. The ATS seamlessly switches between the main power grid and backup sources, such as inverters, using relays for efficient operation. Through rigorous testing and prototyping, the system demonstrates a 66.3% efficiency and a maximum load rating of 10 A, making it a cost-effective solution for emergencies and standby power needs. Future enhancements could focus on improving efficiency through switching power supplies. Overall, the ATS offers a reliable and efficient solution for managing power outages and ensuring continuous power supply.

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