Design And Implementation Of An Automated Multi-Source Selection Smart Uninterruptible Power Supply System

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Abstract-*This research paper focuses on or proposes a smart uninterruptible power supply system with a phase selector and automatic changeover to intelligently manage three distinct power sources, such as the grid, considered the main power supply, the generator, and solar, considered as backup supply systems, to ensure uninterruptible power to critical applications. The novelty of the proposed design lies in its incorporation of the grid, generator, and solar power sources, along with an automatic changeover switch and source selector, and its ability to avert power supply interruptions when any of the power sources is active or present. However, the proposed research aims to address the gap of unreliability in the power supply system presented in the existing literature. The proposed system can detect when all sources are on and only activate the grid relay as the main power source, subsequently switching between the generator and solar when needed, or when one source is off. Besides, the proposed system was programmed using the C++ programming language and simulated using the Proteus software. Moreover, the simulated system was validated via an experimental prototype. Meanwhile, the simulation and experimental results strongly agree with each other, depicting how practical the proposed design is and able to meet or achieve the target of the proposed research.*

key words- Changeover Switches, Generator, Grid, uninterruptible Power Supply, Solar, Smart phase selector

I. Introduction

Continuous supply of electricity or electric power supply to critical sectors or applications, such as medical facilities, in order to avoid situations that may cause the loss of life of patients, hence, the need to continue research to unearth an effective uninterruptible power supply system to avoid or avert the aforementioned situation. Moreover, power supply system failure has emerged as a major or key challenge that hampers national development, owing to the fact that economic activities are most of the time brought to a halt or standstill. Meanwhile, there are key processes, namely, surgical operations in medical facilities or hospitals, interbank financial transactions, etc. [1]. Moreover, to ensure a consistence or continuous power supply system which is indispensable or requisite across diverse sector namely, household and critical institutions or applications like hospitals, research institution and financial institutions, comprehensive research in [2] design and analyzed an uninterruptable power supply which integrates three power sources, namely, grid (main) power, generator power, and solar energy via simulation. However, since this proposed design is an integral and modern solution to ensure a reliable and uninterruptible power supply system, it is imperative to validate the simulated design with experimental prototype analysis to ensure its practical implementation.

Meanwhile, scholars in [3] proposed an automated uninterruptable power supply with a multi-electricity source selection mechanism owing to continuous blackouts or outages that lead to systemic breakdowns, which sometimes cause fatalities, hence, the need for several separate or segregated, varying cost power generated sources for applications such as residences, and industrial (workplace) facilities. Moreover, the power source selection is based on uninterruptible or cost. Besides, the proposed system was effectively analyzed using the Proteus simulation software environment. Nonetheless, the scholars proposed that, to enhance or improve the system performance, an experimental prototype or hardware model must be created or developed and tested to validate the simulation. Furthermore, owing to the rapid or swift growth in the number of power generation sources, covering power distribution networks have developed an urgent necessity for effective power management platforms. Besides, these designed platforms must obviously be able to effectively coordinate, control, and optimize the power operations of respective distributed units in real time to certify energy stability [4].

Meanwhile, the ability or the capacity to supply and provide continuous electric power to consumer-connected loads is a vital goal of the utility companies. Moreover, countries like Ghana and other evolving or developing countries, major institutions such as hospitals and other critical applications, and banks require not be challenged or denied continuous electricity for even a brief period of downtime. Hence, a need to investigate an alternative means or solution for providing or generating electricity via a renewable energy source, namely, solar energy. Besides, the system employs a power electronics device, digital logic gates, and a phase selection mechanism. Even though the design prototype demonstrated a successful design performance in terms of operating speed and three-phase synergy, it is imperative to adopt the miniaturization of the proposed system by the utilization of digital circuit components and the scalability of other key electronic circuit components to enhance the design performance. [5].

Meanwhile, owing to unsteady or attainability of continuous electric power or electricity being supplied to their domestics, commercial, and industrial applications, particularly in evolving countries, hence, necessity for sustainable power supply system is crucial for the aforementioned reason, the system adopts microcontroller based multi-source selection switch with periodic shifts of generators aimed at four distinct sources such as utility, solar and generator to switch between them at six (6) hours interval based on priority. Moreover, the obtained results from the Proteus software demonstrated successful design performance; it is imperative to highlight that the simulation results were not validated via experimental prototype results [6]. However, the primary goal of every and or any electricity supply or power utility supply authority is to effectively ensure a continuous and reliable energy supply to the electricity consumer. Besides, where this goal fails or does not materialize, there is usually an erratic or unstable power supply, which is evident in evolving and developed countries such as Nigeria. Also, the experience of these power fluctuations, phase interruptions, and sometimes absolute power outage or failure negatively affects the country's economic development. Meanwhile, more often than not, the epileptic nature exhibited via the power supply system leads to damage experienced by commercial and domestic electrical appliances and downtime to other critical applications [7].

Furthermore, the provision or planning of alternative power generation sources in the power substations has undoubtedly brought ease in the accessibility of electric power supply; nonetheless, with a supervisory challenge linked with manual switch operation of changeover. Therefore, to ensure fast changeover operation, automated processes must be strengthened, particularly in industries that demand an uninterrupted electric power supply system, namely, hospitals or medical centers and security or protection agencies [8].

Nonetheless, [9] design and implementation of an intelligent three-phase changeover integrated with an automated generator with a run or start and stop control mechanism was extensively analyzed. Furthermore, the system utilized a phase detection sensor to monitor or detect voltage across each phase. Besides, the system focused mainly on the grid as the main supply and a generator as a backup or alternative supply to ensure a reliable and continuous supply by automatically detecting and disconnecting the connected loads from the grid or the main source whenever an abnormality is detected and transferring to the backup supply or the generator by closing contactors via relays. In [10], scholars designed and constructed a hybrid automated power supply changeover switch incorporated with a phase selector mechanism. The system proposed has the capability of switching betwixt three distinct power supply sources, namely public utility power supply, generator source, and inverter circuit supply system. Furthermore, the design was implemented using contactors and relays to energize or effect the switching via a programmed microcontroller to monitor and compare the phase voltage levels in a three-phase supply system with the aid of a simulation via an electrical control technique simulator. However, the proposed system or the scholars did not unveil or demystify what the inverter circuit supply system is, whether it is a solar system or a charged battery connected to the inverter, etc.

Nonetheless, from the aforementioned analysis of the existing literature, it is obvious or clear that there is still the need for continuous research in the field of automatic changeover system for effective and reliable power supply. Hence, this research work aims to design and implement an automated multi source selection smart uninterruptible power supply system to ensure effective and reliable power supply system via an alternative power source, namely, Grid as the main or primary supply and Solar and Generator as standby power supply system.

II. MATERIALS AND METHODS

A. Proposed Design Analysis and Simulation

To ensure easy replication of the proposed design, it is essential to clearly and systematically present the materials and methods in this paper, thereby avoiding any potential misleading of scholars and researchers. The design block diagram representing the key design components is presented in Figure 1. The three distinct power supply units considered are the grid, which serves as the main power supply, and the backup or standby supply, namely the generator and solar sources, which are also present in the block diagram. Besides, the sensor presented in the block diagram does the detection and converts the electrical signals to an appropriate signal to the microcontroller, which is the brain of the proposed system, while the relays disconnect and connect the appropriate switches during abnormal conditions, such as a power outage in one of the distinct sources. Moreover, the LCD indicates or displays the various switching activities and which source is on at a particular time. Nonetheless, it is imperative to highlight that there are components like contactors and interlocks to ensure the safety and smooth operation of the proposed design. The simulation of the proposed design was carried out via the Proteus software. Meanwhile, the load considered during the simulation exercise is a lamp or an electric bulb, as presented in the circuit diagram in Figure 2.

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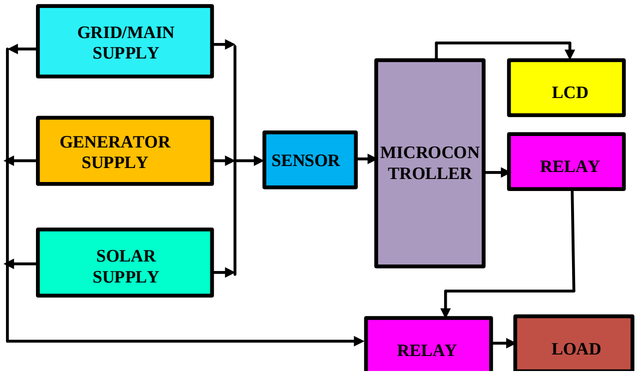

Figure 1. The block diagram of the proposed design

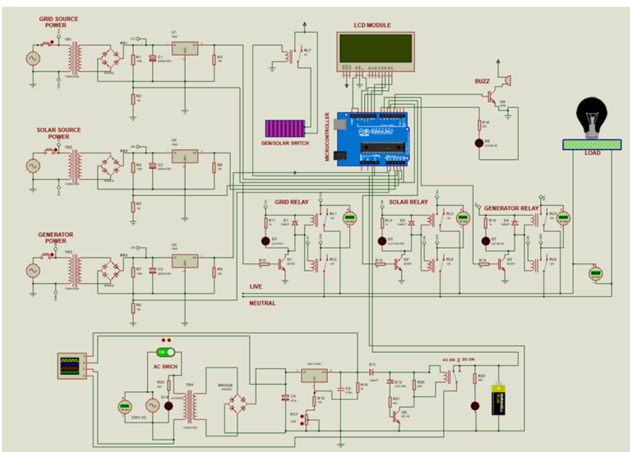

Figure 2. Circuit diagram of the proposed design

B. Design and Construction Analysis

As presented in Figure 3, the various connections and components, such as the relays, microcontroller, and LCD, are connected and fixed, and secured on the breadboard. Furthermore, the continuity and testing of the various components were carried out to ensure effective connections. Nonetheless, a power supply using a step-down transformer, a smoothing capacitor, and a voltage regulator was designed to ensure that a 5V DC was obtained to feed the microcontroller. Furthermore, the are three (3) distinct. 13A socket outlets are adopted to represent or enable the connection of the grid, solar, and generator. Also, the buzzer, relays, and the sensor were configured or connected to the microcontroller to achieve the set target of the proposed design. Nevertheless, the microcontroller was programmed using C++. Moreover, the various connection joints were well soldered using a soldering iron and terminated at the various terminals and separated to avoid a short circuit. Besides, the final packaging depicted in Figure 4 is done using an acrylic material to ensure heat dissipation and effective cooling of the component to avoid thermal runaway.

Figure 3. Construction Process of the Proposed Design

Figure 4. Final packaging of the Proposed Design

III. RESULTS AND DISCUSSION

A. Simulation Results Analysis

The results of the proposed system presented in this section was based on simulation via Proteus software. Besides, the microcontroller was programmed using C++ as the central component or brain of the system, while the relays are employed to energized or deenergized any three of the sources, namely, grid, generator, and solar to the connected loads when the sensors detect which source is active or inactive, hence, demonstrating it automatic changeover switching ability. Meanwhile, the results of the simulation depict that in the initial stage, all sources are active or on but the system give priority to the primary source which is the grid and the generator and solar sources as standby, and this design activities or information are accurately displays on the LCD screen. Nonetheless, the various or distinct results or operation of the sources are presented in figure 5 to 7 respectively, hence, depicting how effective the programming was.

Furthermore, figure 5 illustrates the circuit when the primary source (Grid) is on or active, that is when all sources are on but the grid was selected by the system based on priority and programming. Moreover, figure 6 depict the simulation analysis of the operation where the grid is off, and the system selected the solar source based on priority and running cost. Besides, the final process or analysis which shows the operation via the simulation when both grid and solar are off and the system detect the generator as the available supply is presented in figure 7.

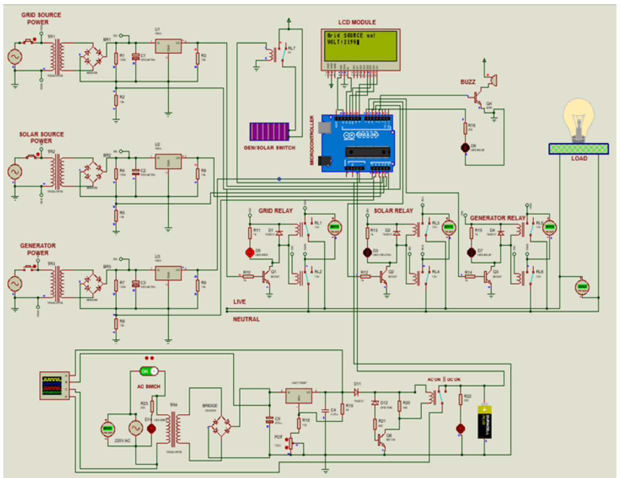

Fig. 5 Result of the simulation of the system when all sources are available, but with the grid relay activated to supply the connected load

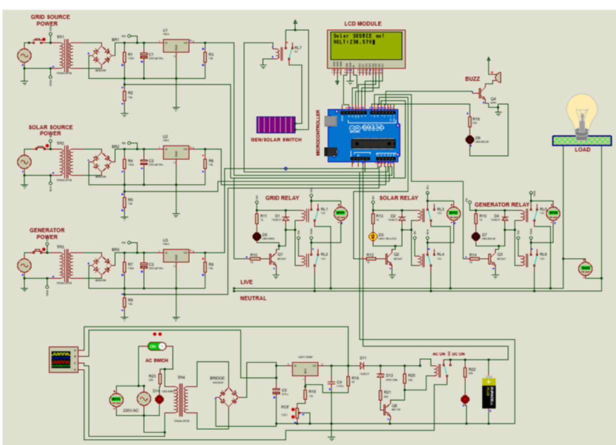

Fig. 6 Result of the simulation of the system when the solar is being activated to supply the connected load

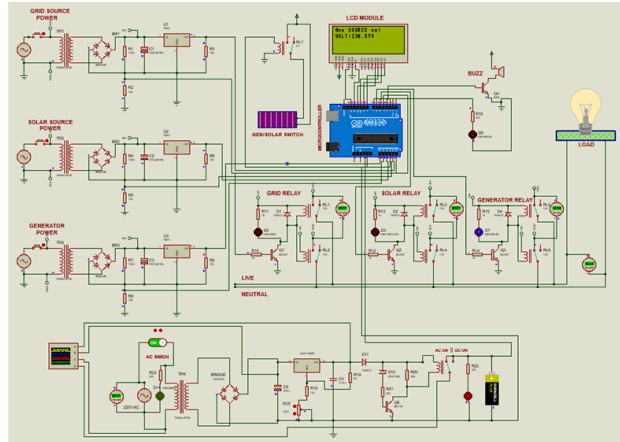

Fig. 7 Result of the simulation of the system when the generator is activated to supply the connected load

B. Experimental Results Analysis

The results of the experimental prototype of the proposed system are presented in this section of the paper to confirm the simulation results and demonstrate the practicality of the proposed system. Moreover, the distinct experimental results are presented in figure 8 to 10 respectively for clarity. Meanwhile, figure 8 depict the practical or experimental test when all the three source are on are available but with only the Grid relay being activated to validate the simulation results. Nonetheless, figure 9 represent the experimental results when the Grid which is the main source is off and the solar source relay is activated with the aid of the sensors. Furthermore, figure 10 shows the experimental operation of the system when both Grid and Solar sources were unavailable and the Generator relay is activated to ensure power supply reliability.

Fig. 8 Experimental test of the system when all sources are available, but on the Grid, relay is activated to supply power to the connected load

Fig. 9 Experimental test when the Grid is off and the Solar source relay was activated to supply power to the connected load

Fig. 10 Experimental test of the system when both Grid and Solar are unavailable and the Generator source relay is activated

IV. CONCLUSION

The design of the proposed automated multi source selection smart uninterruptible power supply was programmed vis the C++ language and simulated using Proteus software. Moreover, the simulated design was successfully validated via experimental prototype. Nonetheless, the results of both simulation and experiment demonstrated that the system automatically and effectively switch between the three (3) sources, namely, Grid, Solar, and the Generator. The system works on the principle of detecting with the aid of the sensors, unavailability of a source and switched to an alternative source automatically to ensure power supply reliability without manual operation. Furthermore, to ensure safe operating mode conditions, distinct colours of light emitting diodes (LEDs) are employed or utilized to clearly show which power source is on at a particular moment. Finally, based on the consistency of both simulation and experimental results, the proposed system was successfully implemented.

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