Design of Smart Phone Automatic Switch for Choosing Optimized Power Source of Different Power Sources

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***Abstract*— The availability and continuity of electricity power are vital. Electricity continuity is highly necessary in places like hospitals that houses the intensive care units, factories, companies, government institutions and public and private educational institutions. This paper aimed to design a smart switch circuit which is able to transfer different electricity sources to guarantee availability and continuity of electricity. The design focused on using environmentally friendly energy, such as solar power. Furthermore, this design helps in reducing dependence on a sole electricity source and avoiding blackout incidents. The design of smart switch contains electronic circuit that transfers electricity from different electricity sources prioritizing the solar power. The design contains Arduino Uno programmed to implement the switching process. The mechanism of the circuit depends on the voltages reading through the voltage dividers where the Uno controller makes a signal indicating the availability of each power source of the solar power source, the main power source and generator source then selecting the optimized one according to the priority of each. The system sends message to cell phone by GSM module to illustrate current situation and a website to monitor smart switch.**

***Index Terms*— Electric Source; Electronic Design; Solar Energy; Switch.**

I. INTRODUCTION

The clean power sources such as wind and solar have been growing around the world. The existence of wide area allows these sources to be generated near the load centers; hence, minimizing the need of expensive high voltage transmission lines, which requires a wide area to reach the rural area [1]. Since electricity power in the developing countries plays an important role in the everyday activities of the people, either at the domestic or public levels, there is a constant need for a continuous and stable power supply. This continuous and stable power supply could not be attained via the primary source of the power plants, which predominantly have a high rate of power outage and frequent power failures. As a result of this power outage, the majority of people at the public and private sectors experience a slow work process. Furthermore, the remote areas may not have the advantage of utilizing the supply of the primary power supply. This necessitates the demand of smart grid, which supplies electricity from alternative sources of power generation and automation of electrical power supply. By doing this, a stable and continuous power supply from different sources is secured throughout the year. Therefore, there is a need to develop a smart switch to transfer or change the different electricity sources that are able to eliminate the element of main power interaction in starting a generator and changing power supply from one source to another. This smart switch senses have the ability to automatically start up the third supply when the mains or public utility supply and the secondary supply are interrupted. Since the emergence of smart grid technologies there have been a lot of effort to upgrade these technologies for the purpose of electronic control, metering, and monitoring. In the 1980s, the first developed technology was the automatic meter reading for monitoring loads from large customers. In 1990, a new generation of advanced metering infrastructure, which has many advantages such as the ability to store consumption of electricity at different times of the day has been developed. Furthermore, the smart meters were featured by using continuous communications, which allows for monitoring in real time [2]. The operation principle of automatic transfer switch (ATS) is as shown in Figure 1, which includes the monitoring of the power supply from a main electricity source and a generator supply. It controls the power flow to the load base on the availability or unavailability of electric power supply from either source. Its main configuration consists of a group of relays contactors and driver's devices. ATS is very useful for user because it allows for efficient time consumption to start a generator and changing power supply from one source to another [3].

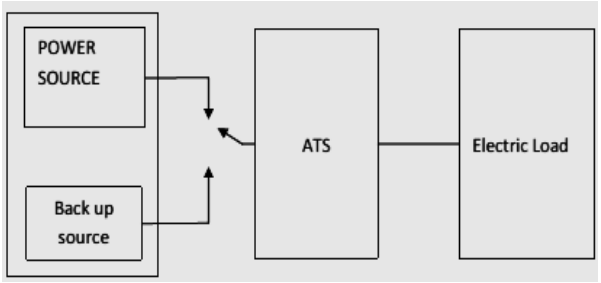

Figure 1: ATS function

II. RELATED WORKS

Developing smart switch for multi-electricity sources has been a research area for a lot of researchers all over the world. There are some differences in terms of the function or the control strategy. Shahaji et al. design power supply Control from different sources, the design used microcontroller and GSM technology [4]. Adeel et al. designed an automatic transfer switch and concludes that it is cost effective [3]. Agbetuyi et al. presented in his paper a design and construction of an automatic transfer switch, which used single power generator only [5]. Eshovo et al. illustrated a

design of automatic switch that can be used for low power only [6]. Zungeru et al. showed a design of smart switch that can be used for personal computers [7]. In Ganiyu et al. a design of smart meter was shown and this design used only to measure the electricity value [8].

III. HARDWARE

This paper is mainly concerned with the strategic component of smart switch design for enhancing electricity continuous and saving energy from power outage. In this respect, this section of the paper is dedicated to explain the design, methodology and procedure of the system.

A. Circuit Elements

The block diagram of the proposed design is shown in Figure 2. For simplicity of understanding, the design of this system has been sectioned into three (3) modules:

- The power module
- The control module
- The switching relays

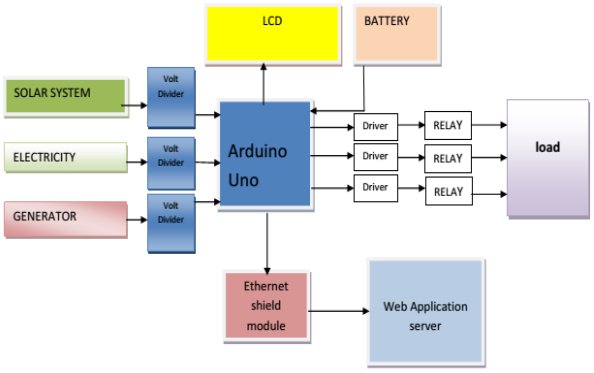

Figure 2: Basic switch diagram

The proposed design as shown in Figures 3 and 4 consist of the following components:

- Arduino Uno
- LCD screen
- Three power sources (solar, main power, generator)
- Transformer
- Transistors
- Resistors
- Bridge (rectifier) LED indicator
- Load (lamp)
- Relays
- GSM module
- Ethernet shield module

The electronic circuit, as shown in Figure 3 contains Arduino board which is programmed to control the circuit. In addition to Arduino, there are a displaying screen, current driver, a voltage divider, rectifier bridge containing four diodes for transferring electricity from AC to DC, transformers to decrease the voltage from 220 to 12 volts, electric load (a lamp), electric source (5 volts), and relays to transfer from one source to another. The transfer from one source to another is done by a certain strategy, which is programmed inside the controller.

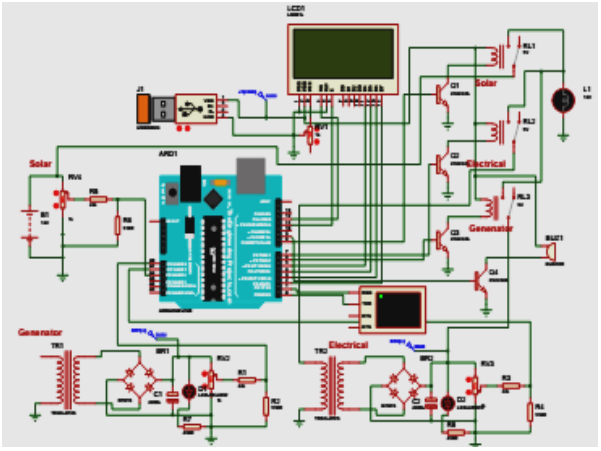

Figure 3: Electronic circuit

Figure 4: Hardware design

IV. OPERATION CONCEPT

The solar voltage can be sensed by downward converting the 12V DC to 5V DC using 25k ohm resistor. When the solar supply is active (9 – 12V), the voltage sensing circuit provides 5V DC, and when the solar supply fails (less than 9V), the voltage sensing circuit gives 0V at its output. The main power is started automatically when the solar fails and the voltage sensing circuit provides less than 9V at its output. Starting the main power requires short the wires connected to switch, which is done by sending signal from microcontroller to relay. The generator ON/OFF switch open or short the two wires connected to it when the generator needs to be switched on or when the generator needs to be turned off. Relays can be used to open or short these two wires to start or stop the generator. The relay coil is energized by 5V DC main supply voltage coming from the microcontroller due to sensing circuit. When the voltage is available, the relay coil will be energized. When the voltage is available, the generator remains off, and the microcontroller will send a signal to relays to keep the wires connected to the generator ON/OFF switch open circuited. When the main power failure occurs (less than 160V), the voltage sensing circuit sends 0v at its output and the microcontroller will send 5v signal to relay. Relay makes the ON/ OFF switch short circuited, allowing the generator to start the circuit. The solar input used a voltage divider to protect Arduino input from high voltage, as shown in equation (1):

$$V_{out} = V_{in}[R_2/(R_1 + R_2)] \quad (1)$$

where: V_{in} = Input voltage

V_{out} = Output voltage
R_1, R_2 = Voltage divider resistors

Here, V_{in} = 12V, V_{out} = 5V, R_1 = 510 ohm, and R_2 = 360 ohm. So, $V_{out} \approx 5V$ as it required of microcontroller input to avoid damage of the microcontroller. R_1 and R_2 refer to the resistors of the voltage divider connected to each power source. Similarly, equation (1) is used for the calculations of electrical input power module and the generator to determine the input of Arduino ports as:

- V_{in} = 220V,
- V_{out} = 5V,
- R_1 = 22 KOhm,
- R_2 = 510 ohm
- 4.9844 V = 220[510 / (22000 + 510)]

V. SOFTWARE IMPLEMENTATION

There are five cases that describe how smart switch works. Figure 5 illustrates the flowchart of the algorithm. The algorithm considers that solar source is the primary supply and it has the priority whenever it exists and provides the required value of volts. The following conditions are the main steps of the algorithm:

- Check all voltage input
- Solar on, Electricity off and Generator off
- Electricity on, Solar off and Generator off, Generator on,
- Electricity off, Solar off and Generator fails to start and Buzzer on

The process of selection and comparison starts, when the solar power voltage is 10 volts or more, the selection goes to the solar power with state (on) and the main power and the generator are on state (off). When the volts of the solar power are less than (10V), the process transfers to the second state, which is the main power if its voltage is more than 160V and less than 230 volts. In this case, the state of the main power is (on) whereas the state of the solar power and the generator are (off). When the solar power is less than (10) volts and the main power is less than 160 or more than 230 volts, the process transfers to the third state, which is operating the generator with state (on) and the state of the solar power and the main power are (off). A backup battery will start working for 1 minute until the generator works.

VI. RESULTS AND DISCUSSIONS

This paper described three operation modes of smart switch as shown in Figures 6 to 8. The results illustrate the three possible modes, the solar mode, generator mode and general electricity mode, in which all are controlled through a pre-programmed software in an Arduino Uno Microcontroller.

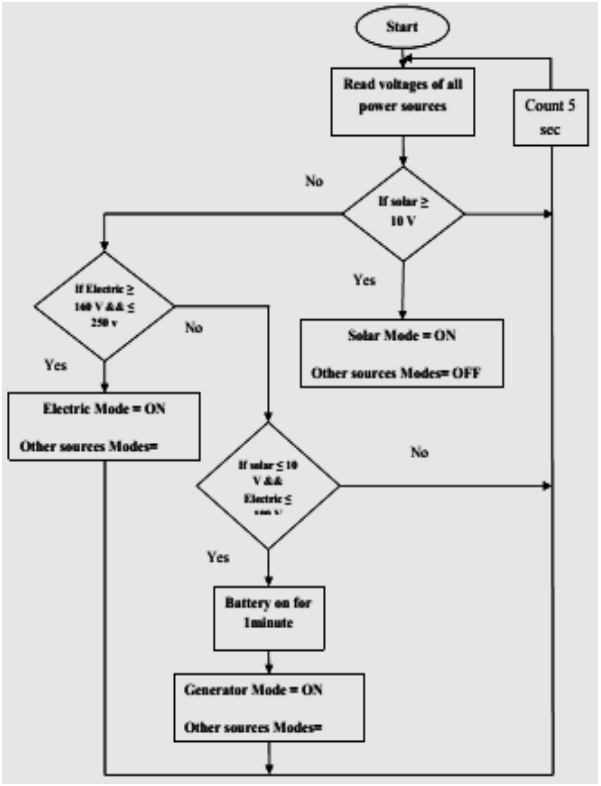

Figure 5: Flowchart

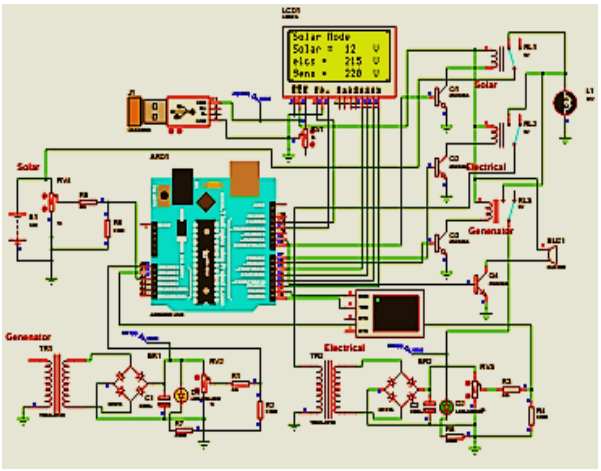

Figure 6: Solar mode

A. *Solar Mode*

Figure 6 illustrates the result of smart switch at the solar mode connection, which allows it to solar power for load. In this case, the voltage of solar source is more than 10V, Elect = 215V, and Generator = 220V. But microcontroller select solar mode, which has the first priority even though the other sources are on the suitable range of voltage. This is because the cost of solar is less than the main Electricity and generator. After that, microcontroller sends a message to GSM and cell phone to inform the user, about this new status wherever he is available.

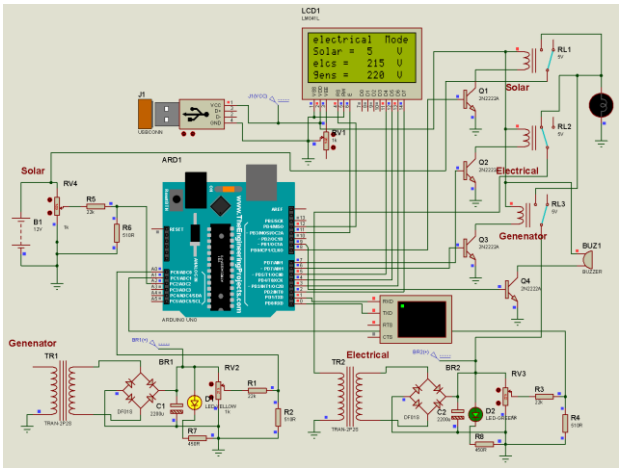

Figure 7: Electric mode

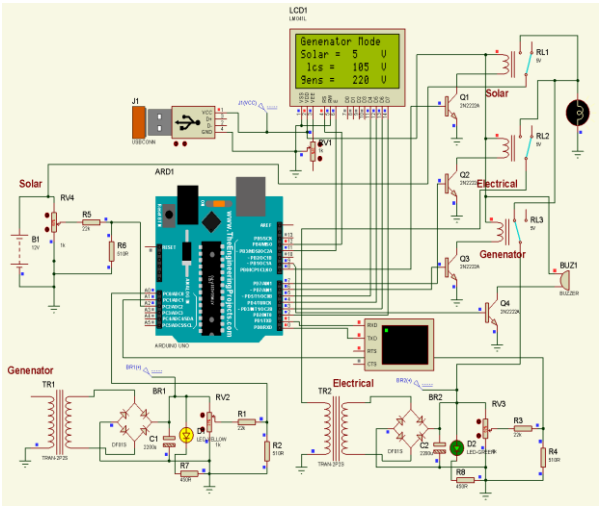

Figure 8: Generator mode

B. *Electric Mode*

Figure 7 represents the power switch operating at main general electricity network mode connection, which allows the electric power for load.

The result of electric mode was examined when the solar volt is less than 10V, Electric is more than 200V and less than 230V, generator = 220V. When the priority of connection was given to electrical mode, the microcontroller sends a signal to open the main electricity power, which then sends a message using GSM to cell phone to update the status mode.

C. *Generator Mode*

Figure 8 represents the smart switch at the Generator mode connection, which allows for generator power for load. Here, the generator is switched on when Solar volt is less than 10 and Main Electricity volt is less than 200v. When the generator mode is "on", the microcontroller sends signal to relay the generator switch to start up, then the microcontroller sends message to GSM and cell phone.

D. *Monitoring Techniques*

There are three methods of monitoring the status of power provided by this design:

- LCD
- GSM message
- Web page

The purpose of showing the instantaneous status of each source in different ways is to ensure easy monitoring for user. Figures 9 to 11 illustrate the results appeared in each power mode, which were carried out in the GSM message, LCD and web page. As shown in Figure 9, when the solar source exists, other backup sources were closed even if they were available because solar has the priority. This design also offers a daily report that provides the status of the power sources over the day.

Figure 9: Solar mode results

Figure 10: Electrical mode results

Figure 11: Generator mode results

VII. CONCLUSION

The smart switch power circuit in this paper is designed as a replacement technique, which can be used for the future as

a solution of power system resources. The significance of this paper is combining three or more facilities of electricity resources the mean priority is for the renewable energy system. In this prototype system which was controlled with an Arduino Uno microcontroller system, the three power sources were the solar energy, the generator system for emergency states, and the main general electricity source. The overall results were accurate, and a convenience modern energy system with a high grade of reliability and stability has been proposed.

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