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Development of Automatic Switch for Electric Power Transfer †

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Abstract: This article addresses the issue of power outage while transmitting electric power to consumer's end. Electricity demand in today's world has risen sharply where it must be generated not only using conventional fuels, but also from renewable sources in order to meet this demand. In this regard, an automatic switch is being developed that allows switching between sources in such a way that first and foremost, electric power from solar and wind farms is transferred to the consumer or to the general network. It not only resolves the issue of unforeseen blackouts and power outages, but it also ensures that the consumer end is receiving voltage from a stable generating source. This is how the automatic switch will work effectively in the best interests of the consumers.

Keywords: switching device; power plant; general network; renewable energy resources; bridge rectifier; smoothing capacitor; buffer amplifier; liquid crystal display; relays

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1. Introduction

Electric power is generated in many countries around the world at power plants that use not only traditional types of fuel, but also renewable energy resources. Simultaneously, electric power transmission in the general network is carried out without regard for the work of solar and wind farms, except during specific periods of time associated with the time of day or the change in wind mode [1]. Our primary concern is the quality of electricity that is exported to consumers. The main objective of this project is to develop a device for measuring the transition between two electric signals. Voltage fluctuations in the power system are caused primarily by transmission line impedance, load type, and an uneven one-phase load distribution [2].

A voltage imbalance can be caused by an imbalance in the power system's load, unbalanced impedances, or asymmetric failures. It is also necessary to consider the application of various techniques used to mitigate the various problems associated with power quality [3]. Aside from fossil fuels, renewable energy sources have become more important than ever before as fossil fuels are depleted. The exchange of power between fields is based on the balance of production and demand in each field. The issue is twofold: load cannot be regulated, and wind turbines produce unpredictable electricity. In the electronic power circuit, the AC to DC and DC to AC converters are typically connected back to back [4]. Wind power plants' maximum net capacity increased globally from 553 MW in 2007 to 466,505 MW in 2016 [5]. Wind energy's rapid development over the last decade has demonstrated its high potential in comparison to the costly and complex tool that complicates the repair process and necessitates an evaluation of its reliability [6].

2. Methodology

This part of the paper provides the structure and workings of our automatic switch, as well as an overview of the rest of the paper. It is divided into sections. Section 2.1 uses a block diagram to describe the structure of an automatic switch. Section 2.2 contains

the working of experimental work that is carried out. Section 2.3 contains the schematic diagram of any power source.

2.1. Block Diagram of Automatic Switch

The methodology of the proposed automatic switch can be easily understood using the block diagram. The operation of the switch device (Figure 1) is coordinated by means of the program written on the Arduino.

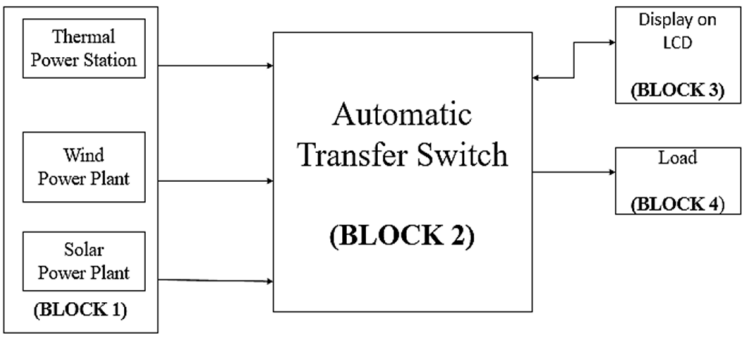

Figure 1. Block diagram for automatic transfer switch using Arduino (IDE).

Block 1 represents three power supplies, which come from a wind power plant, a solar power plant, and a thermal power station, respectively. These three power sources perform best under three distinct conditions. Without accumulation blocks, solar power plants can only transfer electricity to the general grid during the day, whereas wind power plants can only do so when the wind speed is sufficient to start the wind turbines. At the same time, thermal power station energy generation is not effected by external factors and can remain constant.

Block 2 indicates automatic transfer, which is our primary concern. It is composed of five components: a bridge rectifier that converts the AC single-phase supply to DC, a smoothing capacitor that smoothes out the fluctuations in the DC volts, a buffer amplifier that maintains the voltage level, the programmed microcontroller Arduino that is the brain of this automatic switching, and the relays that is signalled by the microcontroller to select the suitable power source.

Block 3 represents the LCD on which the results are displayed. It is accomplished with the assistance of the Arduino program.

Block 4 represents the load at which a specific relay of a power station is signalled by Arduino to supply power.

2.2. Working of Automatic Transfer Switch

The single-phase supply voltages arrived from power sources, so there is a need to convert this 220 V of AC to 5 V DC to provide require voltage for Arduino. Firstly, the voltages are stepped down, and then rectified into DC voltages. Following that is a smoothing capacitor, which will act to smooth or even out fluctuations in a voltage signal.

For obtaining the required 5 V for Arduino, voltage divider circuit is used and after that buffer amplifier with unity gain is connected that will maintain the voltage level without amplifying it.

Assume a single-phase supply of 230 V comes from a Solar Power Source. This voltage must be converted to 5 volts DC. It is done to power the Step-down transformer, which is connected to the bridge rectifier and will convert the voltage from alternating current to direct current. Following that is a smoothing capacitor, which will act to smooth or even out fluctuations in a signal.

With the aid of a DC Voltmeter, the voltage can be calculated to be 34.9 V. Now, in the next voltage dividing circuit, resistors are used because it has the ability to adjust voltage to 5 V or less with respect to the voltage coming from behind.

Following that, a unity gain buffer amplifier is connected to reduce the ripples in the voltage and maintain the voltage level without amplifying it. We use an operational amplifier with voltages set to positive and negative fifteen volts. The Volts here can be measured across a specific pin of the Buffer amplifier using a DC Voltmeter and will be 4.99 V.

It is already pre-programmed with the code that will power it. Now is the time for Arduino to operate at the desired voltage. Now, at the power station where the load is to be shifted, the Arduino will signal the relay, and its pin will become LOW, triggering the system. The output can be displayed on the LCD.

2.3. Schematic Diagram of Any Power Source

A schematic diagram shown in Figure 2 can help you understand how an automatic transfer switch works. Experimental implementation of this schematic diagram is also shown in Figure 3.

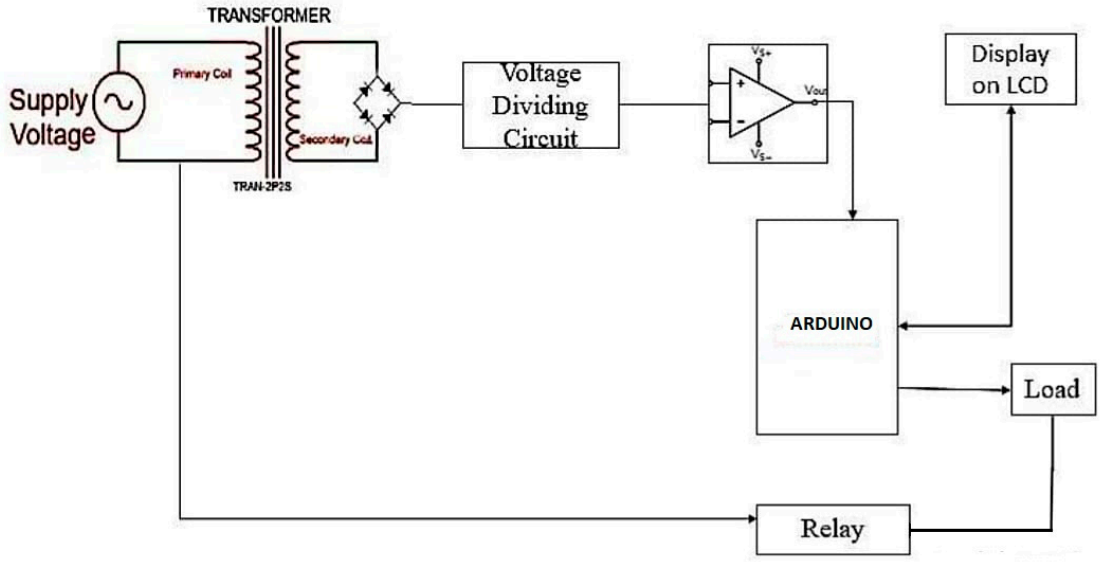

Figure 2. Schematic diagram of any power source.

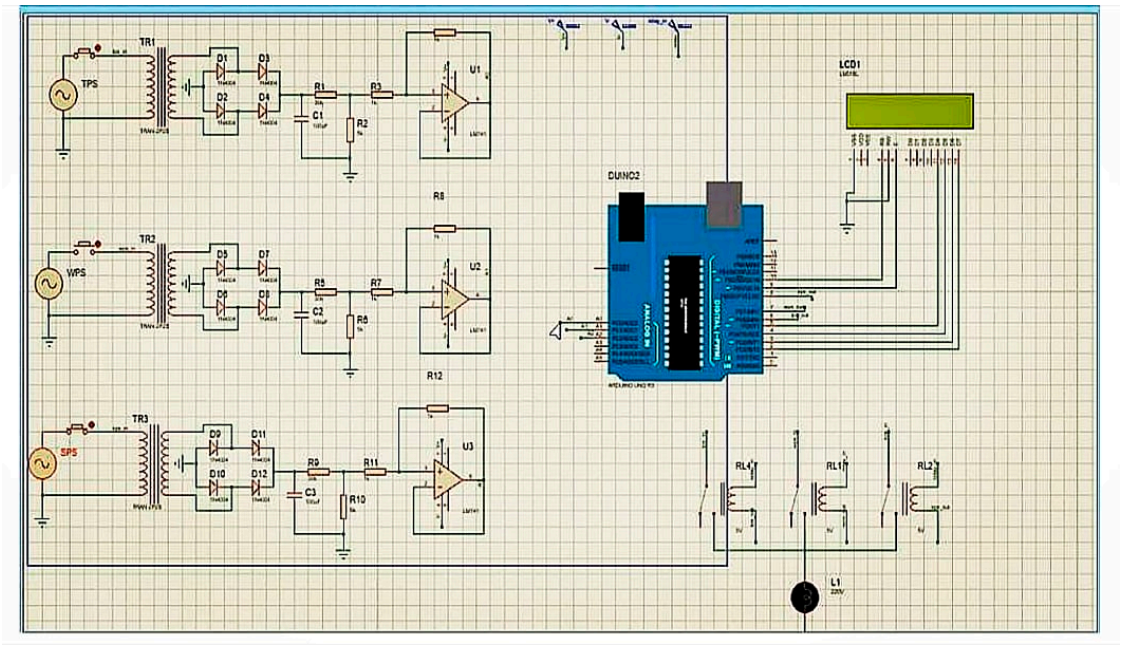

Figure 3. Experimental implementation.

3. Results

When we run the simulation on Proteus using Arduino programming, the following results are displayed on the LCD.

The automatic switch that is being developed on selecting that specific generating station that is supplying stable power supply. Furthermore, the order of selecting power plants will be determined. First, a solar power plant, Second Wind Power Plant and the last priority is a thermal power plant as it is dangerous for environment.

Arduino performs signal processing on the set program and provides control instructions for switches and relays for commutating generated electrical energy to corresponding consumers, which can include residential areas, businesses, and the general network.

Arduino runs this simulation by following four regulations. If all three power sources are connected and the thermal power station has 220 V while the others have less than 150V, the Arduino will signal the relay connected to the thermal power station where the load is to be shifted, and its pin will become LOW, triggering the system. The system will select a thermal plant as the output. If all three power sources are connected and the thermal power station has 220 V and the others have less than 150 V, the Arduino will now signal the relay connected to the solar power plant where the load is to be shifted, and its pin will become LOW, triggering the system, and the load will be switched towards supply coming from SPP and the output will be system will choose thermal power plant.

However, if all three power sources are connected and all three power stations have 220 V, the Arduino will now signal the relay connected to the solar power station where the load is to be shifted, and its pin will become LOW, triggering the system, and the load will be switched towards supply coming from SPS as it is more environmentally friendly, and the output will choose solar system.

In Figure 4, the programmed Arduino signals the LCD for half a second to show the title of the project. In Figure 5, the programmed Arduino signals the LCD for half a second to show the name of the first member. In Figure 6, the programmed Arduino signals the LCD for half a second to show the name of the second member. In Figure 7, the programmed Arduino signals the LCD to display total voltages starting from the voltages of thermal power station.

Figure 4. Display of title on LCD.

Figure 5. First member name display.

Figure 6. Second member name display.

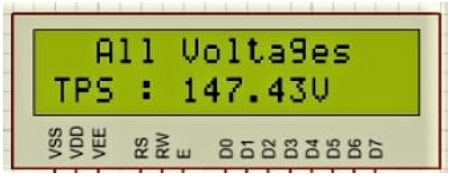

Figure 7. Display of total voltages.

In Figure 8, the programmed Arduino signals the LCD to show voltages of wind power plant and solar power plant. In Figure 9, the programmed Arduino signals the LCD to show the system response with respect to the voltages.

Figure 8. WPS and SPS voltage display.

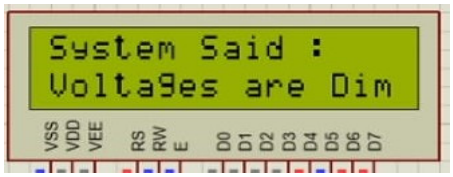

Figure 9. System output name display.

4. Conclusions

These automatic switches are ideal during power outages. It is preferable to install them at the consumer end to ensure consistent supply. Sudden brownouts and voltage fluctuations, as well as outages, blackouts, and bad weather, have increased market demand for transfer switches. The growing reliance on power and critical applications in industries, commercial institutions, healthcare, transportation, and households is driving the transfer switch market. Transfer switch installation is more common in the industrial sector because most industrial end users rely on continuous power.

Institutional Review Board Statement: Not applicable.

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