Arduino Based Efficient Energy Storage Systems Using Solar and Wind Power

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***Abstract*— The aim of this work to investigate and create a solar-powered UPS for the Bangladeshi market as an alternative energy source. It comprises of a design that was created based on our study. Solar and wind UPS systems are made up of a solar charge controller with inverter circuit, and solar panel. Many circuit simulations were performed during this procedure to meet the work's requirement. It also demonstrates that solar and wind-powered UPSs will be very effective and profitable in the electrical UPS industry. In this project, the solar panel is made up of solar cells that convert solar energy into electrical energy. We also have a charging circuit that charges a 12V DC (direct current) battery and an inverter circuit that converts the voltage to AC (alternative current).**

***Keywords* — Arduino Uno, Dumb People, Sensor, Microcontroller, Communication.**

I. INTRODUCTION

Solar power and uninterruptible power supplies (UPS) are two fast increasing technologies. The trend toward cheaper solar cells is driving demand for solar energy, making it economically viable for a wider range of uses. Solar power has yet to reach grid parity in many locations, therefore finding ways to lower the cost of solar power systems is critical. This thesis looks at the feasibility and possible economic synergies of merging solar electricity with UPS systems, which has hitherto only been looked into from a technical standpoint. Instead, this thesis investigates the possibility that, even in a stable power grid, a combined solar and UPS system might save money over traditional grid-tied systems.

The main reason is because UPS systems rectify and invert all electricity, which implies that solar energy may be transmitted to the UPS system's DC component rather than the AC grid, avoiding the need for extra inverters in the solar power system. The economic analysis demonstrates that a combined system has the potential for reduced investment costs due to lower component costs as well as improved energy savings due to lower conversion losses. The study found that combining solar energy with a UPS system is theoretically viable. Furthermore, a combined system outperforms two independent systems in terms of cost. This implies that a combined system may be economically advantageous even when a single system is not [1].

The major goal of this project is to develop a smart system that allows us to derive several benefits from a single effort. Solar panels and wind power may be used to create electricity. Intelligent charging adapts to low, high, and more and less power cut locations, as well as battery health [2].

An inverter for solar and wind power has a 220 V input, PV input, battery input, wind input, and AC output. The inverter, which is at the core of this system, is recognized for its high efficiency and dependability. Batteries are also included in this setup. The solar panel and wind output and input to the inverter / battery are managed by the charge controller. It may provide electricity to loads from PV and wind sources, batteries, or all at the same time. Solar panels and wind, as well as charge controllers, batteries, and inverters, will be used to generate power in this system. We will both provide and utilize power to the grid. Even though there is no fabrication at this time, the project is deemed a success. We also have a load voltage, solar voltage, wind voltage, and battery charge monitoring system that can be viewed on the display in addition to our project. The output of the sensor is constantly checked by the microcontroller.

When it operated in standalone mode, AL.Chockalingam and his team struck an agreement regarding a Hybrid Solar and Wind Energy System employing a four port DC to DC converter in integrated form.

The major benefit of employing a four-port DC-DC converter is that it may be used with a variety of renewable energy systems with different current and voltage characteristics [3]. Aashish V and his colleagues looked at voltage control in a dc microgrid. A photovoltaic panel, battery supply, constant resistance, and power loads made up this microgrid [4]. Mohamed El Amir Attalla and his team created a prototype of the management control system, which was tested in various operating modes of the proposed unit. The satellite power supply management controller was modelled and built-in practice [5].

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Solar and wind power charge controllers are used in a variety of applications, including solar home systems, hybrid systems, and solar water pump systems. Solar panels use an electrochemical technique, also known as photovoltaics, to convert sunlight into electrical energy. With the aid of a charging circuit that includes a diode and a fuse, energy is stored in the battery. In the event of a power outage, this energy will be utilised. Chemical energy is transformed to electrical energy in the battery, which then illuminates electrical appliances or aids in the pumping of water from the earth [6]-[8].

II. System Design

When solar DC power is not available, the residence is supplied by a lower voltage single phase AC power grid (of 90 V) via a rectifier and buck converter that maintains a constant 13.6 V DC output. When the other two sources of power are absent, the battery is charged either from rectifier AC or from solar PV. A microprocessor guarantees that this 100W Dc house receives electricity for the longest possible duration at the lowest possible cost. A continuous flow of electricity is crucial for mission-critical electrical loads. Data centers, life support systems, navy ships, scientific research facilities, and communications networks are examples of this type of technology. Even if the power outage is only for a fraction of a second, slight voltage changes can cause these loads to fail. Our UPS system was designed to rectify grid electricity to DC voltage and then invert it back to AC [9], [10].

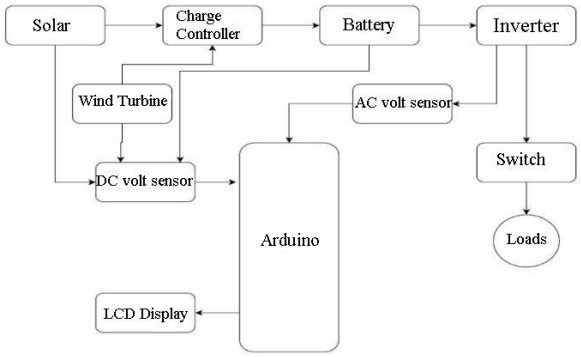

Fig. 1. Block diagram of the proposed system.

When a problem in the main utility occurs, an Uninterruptible Power Supply (UPS) acts as a backup source of electricity that protects loads. Because the primary goal of a UPS is to be always available and hence uninterruptible, the power supply is referred to as uninterruptible. UPS systems are classified as either static or rotary, depending on whether the system is powered by battery storage or rotating mechanical energy [11], [12].

The online UPS (also known as double conversion), the offline UPS (sometimes known as passive stand-by), and the line interactive UPS are three types of static UPS systems with differing topologies and purposes. The rotating UPS system will be excluded from coverage. Out of the three static UPS designs, the Offline UPS is the most basic operating UPS. The load is exclusively provided by AC power from the main utility supplier during normal operation, and the storage battery capacity is charged. A solar cell (also known as a photovoltaic cell) is an electric device that transforms sunlight into electricity. A solar panel is made up of multiple solar modules, each of which is made up of several sun cells. A solar array is made up of multiple solar panels that are connected together [13]-[15].

One of the fastest-growing renewable energy technologies is wind power. Globally, usage is increasing, partly due to lower costs. According to IRENA's latest data, global installed wind-generation capacity onshore and offshore has expanded by about 75 times in the last two decades, from 7.5 gigawatts (GW) in 1997 to 564 GW in 2018.

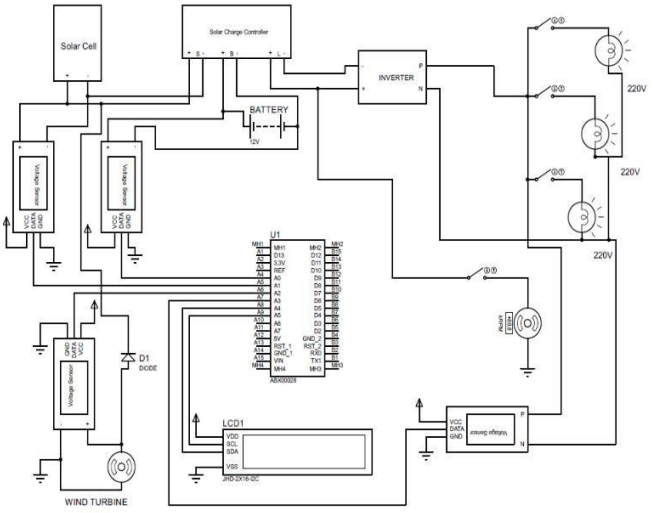

Fig. 2. Circuit diagram of the proposed system.

Wind energy production more than quadrupled between 2009 and 2013, accounting for 16 percent of all renewable energy generation in 2016. Wind speeds are significant in many places of the world, but the ideal spots for generating wind power are often isolated. Offshore wind power has a lot of promise [16].

The battery will be charged through a diode, preventing it from being discharged in the event of a solar power outage. Charging time of battery = Battery Ah / Charging Current.

$$T = \frac{Ah}{A} \quad (1)$$

where, T = Time hrs, Ah = Ampere hour rating of battery, A = Current in Amperes.

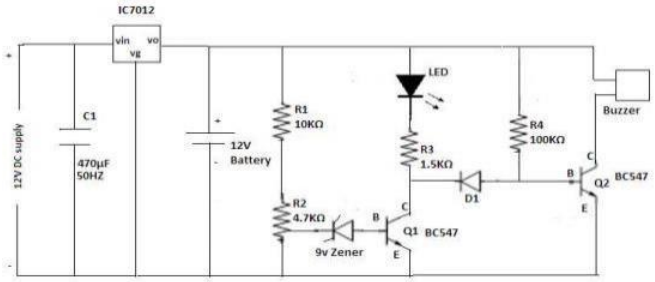

Fig. 3. Battery Charger Circuit.

IRFZ44 provides a high current to the step-up transformer, allowing electricity to be provided alongside the high voltage transformer. Push Pull connections are used to connect the power MOSFETs (Power amplifier). The MOSFETs will switch in response to the CD4047 multivibrator's pulse. As a result, an AC voltage is passed to the transformer's primary,

which is then stepped up to 230 V. An conventional step-down transformer is utilized in this application, and it is wired in inverted mode. For this inverter project, the main of a 230V to 12 V-0-12 V step down transformer can be used as the secondary. This circuit outputs 220 V 50 HZ from a 12 V input (12V battery) [17]-[20].

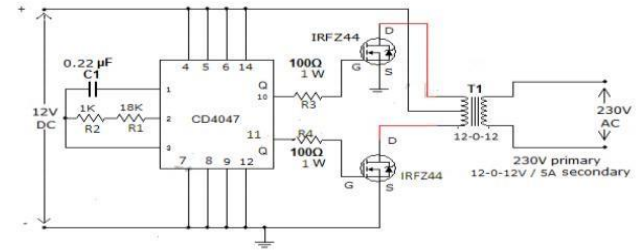

Fig. 4. Inverter Circuit

This board is based on the Arduino Nano R3 and is completely compatible with it. The Roboduino Nano R3 is a breadboard-compatible surface mount version of the popular Arduino microcontroller. It's compact, has an integrated USB port, and can be used with a breadboard. It offers a lot of the same features as the Arduino Duemilanove, but it comes in a different packaging. Although it lacks a power connector, it can nevertheless detect and switch to a greater potential source of power. It's ideal for incorporating into your next work [21].

The Arduino IDE has specific code structure guidelines to support the languages C and C++. The Wiring project is a software library that is included with the Arduino IDE and provides numerous common input and output processes. User-written code only needs two simple methods to start the sketch and run the main program loop, which are built and linked into an executable with a program stub main.

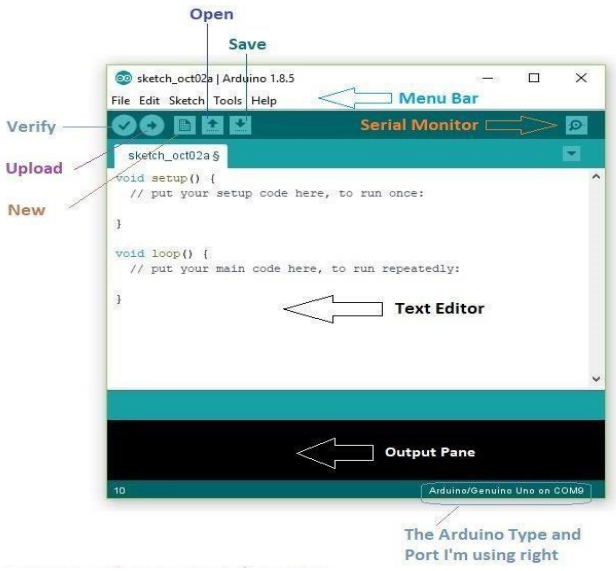

Fig. 5. IDE software.

The devices that absorb the sun's rays are known as solar panels. Using them to gain power. A sunlight-based board is a collection of sun-based (or photovoltaic) cells that may be used to generate electricity via photovoltaic effect. On the surface of sun-based boards, these cells are organized in a lattice-like pattern. The majority of car batteries are 12 V lead-acid batteries. A 12-volt lead-acid battery is found in nearly every automobile, motorbike, and tractor. For a short amount of time, these batteries may deliver hundreds of amps of electrical power [22].

A voltage sensor is a device that calculates and monitors the amount of voltage present in a given item. Both the AC and DC voltage levels may be determined using voltage sensors. The voltage may be used as the sensor's input, and the switches, analog voltage signal, current signal, audio signal, and so on can be used as the sensor's output. From 0.0245 V to 25 V, the Voltage sensor can detect the supplied voltage. The resistor divider technique is used in this module. The input voltage may be reduced by 5 times using this module.

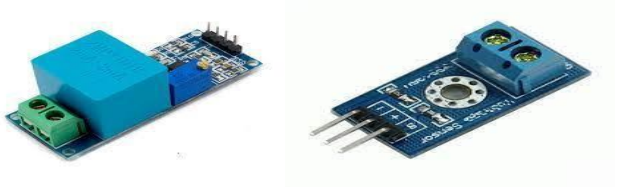

Fig. 6. Voltage sensors.

III. Hardware and Software Setup

One of the most important aspects of the project, the controlling and protection system, is the software. The algorithm is based on a variety of situations and measurements. The software is in charge of the entire system's operation. The code is written in the C programming language. A section titled "flowchart" is required in each programming project.

We created a project flowchart and then typed our suggested project program according to the guidelines. Our project is divided into different sections, which necessitated the creation of numerous flowcharts.

The software used to program the microcontroller is open-source and available for free download. We can develop little programs with the microcontroller using this "Arduino software." "Sketch" is the name of these applications. Finally, using a USB cord, the drawings are transmitted to the microcontroller. More on the concept of "programming" later.

Proteus 8 is the greatest simulation software for diverse microcontroller designs. Its popularity stems from the fact that it contains practically all microcontrollers. As a result, it is a useful tool for electronics hobbyists to test applications and embedded systems. In Proteus 8 Simulation Software, you may simulate your microcontroller programming. After modeling your circuit with Proteus 8 Software, you may go straight to PCB design, making it a one-stop shop for students and hobbyists. So, I believe you now have a basic understanding of what proteus software is. Proteus 7.0 is a Virtual System Modeling (VSM) tool that co-simulates full microcontroller-based systems by combining circuit simulation, animated components, and microprocessor models.

Engineers may use this application to test their microcontroller designs in real time before building a physical prototype. This application allows users to interact with the design via on-screen indications, LED and LCD

displays, as well as switches and buttons if the PC is connected. The Circuit Simulation module in Proteus 7.0 is a product that combines a SPICE3f5 analogue simulator kernel with an event-driven digital simulator to allow customers to use any SPICE model from any vendor. Breakpoints, single stepping, and changeable display are all included in Proteus VSM, allowing for a clean design before to hardware development. In short, Proteus 7.0 is the tool to use when you wish to mimic the interaction between microcontroller software and any analog or digital electrical device attached to it.

There are several advantages in our line of business. It has very high reliability (combines wind and solar power), long-term sustainable development, high energy production (since both are complementary to each other), cost savings (only one-time asset), low cost of maintenance (nothing to replace), long-term warranty, no pollution, clean and pure energy, offers uninterrupted power supply to the instrumentation, the system provides quality power out-put DC to straight charge the battery storage or provide AC, the system can withstand extreme temperatures, the system can withstand extreme temperatures, the system can withstand [23].

This work can be used in smart Home Automation, Power Grid and industry.

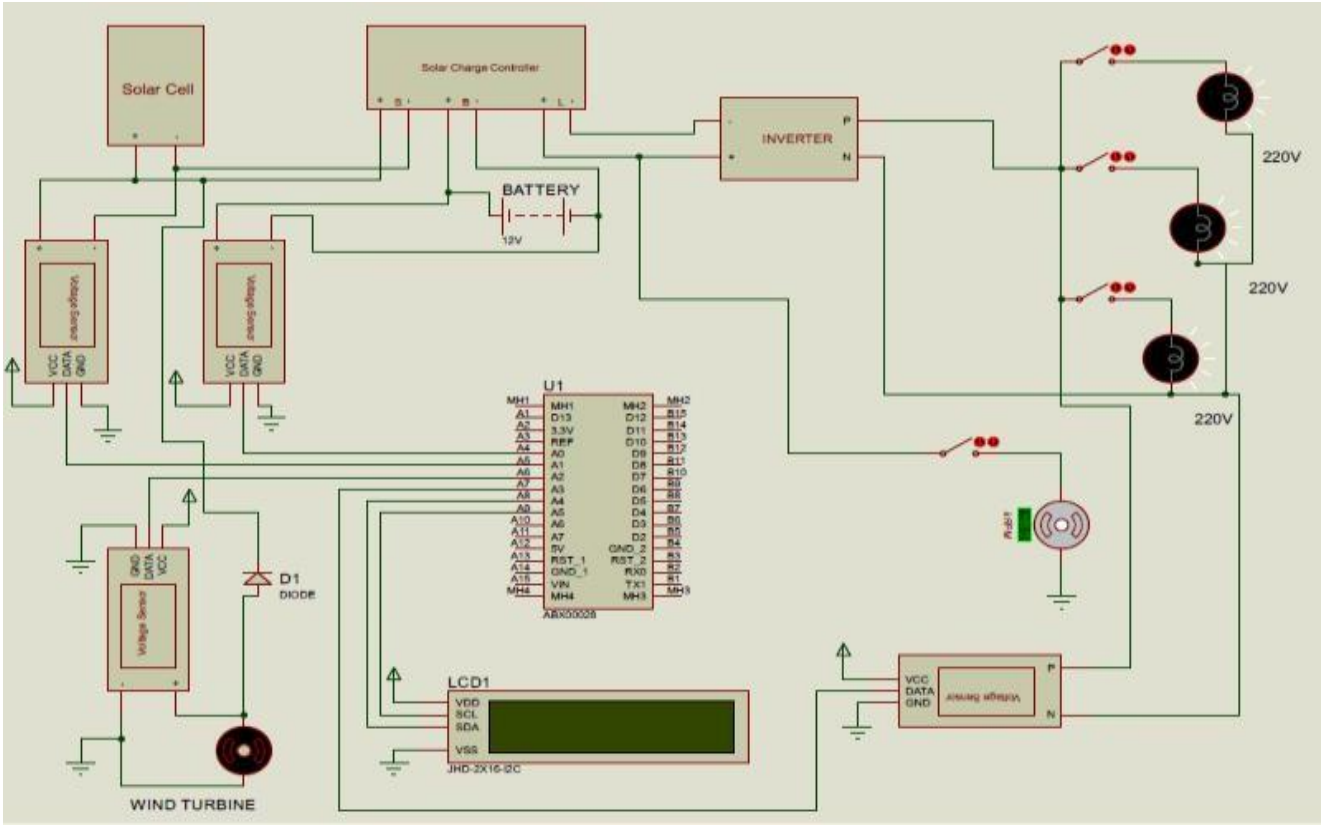

Fig. 7. User interface of proteus 8.1.

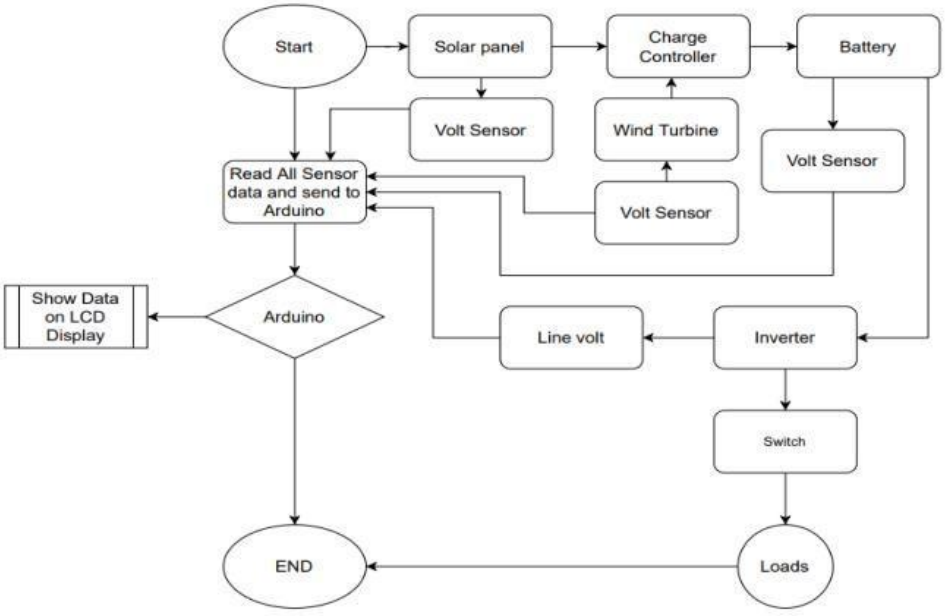

Fig. 8. Hardware implementation of this work.

IV. Results

The rate at which electric current is added to or extracted from electric batteries is limited by a charge controller, charge regulator, or battery regulator. It protects against overcharging and overvoltage, which can impair battery performance and longevity while also posing a safety concern. Depending on the battery technology, it may also prevent a battery from totally draining ("deep discharging") or execute regulated discharges to extend battery life. The phrases "charge controller" and "charge regulator" can apply to separate devices as well as control circuitry included into a battery pack, battery-powered device, or battery charger.

Fig. 9. Hardware Implementation of this work.

We are able to accomplish the following results as a consequence of our proposed system's design and implementation: after the launch of our project, we will be able to monitor load voltage, wind voltage, solar voltage, and battery level from the task display.

TABLE I: Cost Analysis of This System

Components Name	Quantity	Unite Price	Total Price (BDT)
Arduino Nano	1	540	540
Solar Panel 20w	1	840	840
Battery	1	1,500	1,500
Ac Voltage Sensor	1	350	350
DC Voltage Sensor	3	120	360
Buck Module	1	70	70
Charge Controller	1	180	180
LCD Display	1	450	450
Dynamo Motor	1	200	200
Inverter	1	850	850
Others		1,000	1,000
Totally Cost			6,340Tk

Fig. 10. Output on LCD display.

V. Conclusion

This can be accomplished by either integrating new UPS units to feed the workloads or by operating existing UPS units in parallel with new UPS units. Due to its numerous benefits, photovoltaic and wind power generation is rising in popularity as a sustainable energy source. These benefits include a pollution-free energy production plan that lasts forever, ease of maintenance, and direct conversion of solar radiation to electricity. However, the expensive cost of PV installations remains a barrier to this technology's adoption. Furthermore, the output power of PV panels varies depending on weather conditions, such as insulation level and cell temperature. switched to using renewable energy sources. More breakthroughs in this industry are expected to transform the energy supply, with solar energy playing the most crucial role of all. The current implementation, which follows the system's defined design, will result in the project's expected outcome. From a DC source, the inverter will provide an AC source. The stated project is valuable because of the attractive potentials it contains, which range from long-term economic rewards to significant environmental benefits. This endeavor will be one of the few initiatives and contributions in the Arab world in the field of renewable energy where large-scale projects may be implemented.

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