Design and Development of a Prototype for electricity generation using Hybrid power source

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DEPARTMENT OF MECHANICAL ENGINEERING

SONARGAON UNIVERSITY (SU)

DHAKA, BANGLADESH

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DECLARATION

We hereby declare that this thesis is our own work and to the best of our knowledge it contains no materials previously published or written by another person, or have been accepted for the award of any other degree or diploma at Sonargaon University or any other educational institution. We also declare that the intellectual content of this thesis is the product of our own work and any contribution made to the research by other with whom I have worked at Sonargaon University or elsewhere, is explicitly acknowledged.

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CERTIFICAITON OF APPROVAL

This thesis title “Design and Development of a Prototype for electricity generation using Hybrid power source” submitted by Md. Mostahakam Billah (ME2002021147), Md. Serajul Islam (BME2001020504), Shaowmitro Das (ME2002021211), Ripon Chandra Roy (BME1903019326), Md. Sahidul Islam (BME1803016402) has been accepted as satisfactory partal fulfilment of the requirement for the degree of bachelor of science in mechanical engineering on 25th December 2023.

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ABSTRACT

The increasing demand for sustainable and reliable energy solutions has prompted the exploration of hybrid power systems that combine multiple sources to optimize electricity generation. This research focuses on the design and development of a prototype aimed at harnessing energy from hybrid sources to enhance the efficiency and reliability of electricity generation. The hybrid power system integrates renewable sources, such as solar and wind, with a conventional energy source to create a synergistic and balanced approach to electricity generation. The prototype incorporates advanced control algorithms and smart grid technologies to manage the seamless integration of diverse energy inputs and ensure a steady power output.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

In recent years, there has been a growing interest in developing energy-efficient and sustainable systems to meet the increasing demand for electricity. This paper presents the design and implementation of a hybrid system for AC applications, leveraging the capabilities of Arduino microcontrollers to achieve intelligent and adaptive control.

1.1 Background

The proposed hybrid system combines traditional AC power sources with renewable energy inputs, such as solar panels or wind turbines, to create a more resilient and eco-friendly power supply. Arduino, a versatile and widely-used open-source hardware platform, serves as the central controller for monitoring, managing, and optimizing the power flow within the system.

This system works in two-ways — the supply of electricity can flow from the grid to which it is connected to the user's home and from the user's home to the grid. This feature makes the on-grid solar system affordable and highly useful. The solar panels, installed on the user's home are 'tied' to the grid. The solar panels convert sunlight into electric energy, which is Direct Current (DC). This current is then sent to an inverter. The solar inverter then converts the DC to Alternating Current (AC), thus making it power the electrical items. This electricity is then routed to the grid where it is supplied for day to day use. The grid tied inverter additionally regulates the amount and voltage of electricity fed to the household since all the power generated is mostly much more than a home needs or can handle. An important feature is the net meter. It is a device that records the energy supplied to the grid and the energy consumed. At the end of each month, the outstanding is recorded and the consumer is provided with a bill. This 'converted' power supply is then used by homes through the main electricity distribution panel. A DC on grid is equipped with AC/DC sources, DC loads and battery storage systems. Hence, it is capable of operating both in islanded and grid connected mode. A high output voltage is achievable with this converter which is independent of the transformer turns ratio. Multiple outputs can also be obtained by using multiple windings in the secondary of the high frequency transformer. Due to these above advantages a flyback converter is used to interconnect DC on-grid .

In this work, a brief description of the structure of a DC micro grid and flyback converter is provided. The interconnection scheme is explained elaborately. Finally interconnection of more than two DC micro grids, through a multiple winding transformer is proposed.

The arrangement of solar modules absorbs the sunlight on them and convert them into electricity. The current generated here is Direct Current (DC). The solar inverter then converts the DC to Alternating Current (AC), thus making it power the electrical items. This electricity is then routed to the grid where it is supplied for day to day use. An important feature is a net meter. It is a device that records the energy supplied to the grid and the energy consumed. At the end of each month, the outstanding is recorded and the consumer is provided with a bill.

1.2 Features of Hybrid system

This Hybrid system are a growing segment of the energy industry, representing a paradigm shift from remote central station power plants toward more localized, distributed generation—especially in cities, communities and campuses. The power to isolate from the larger grid makes hybrid resilient, and the ability to conduct flexible, parallel operations permits delivery of services that make the system more competitive.

1.3 Objectives of the Project

The objectives of a hybrid system with AC (Alternating Current) integration using Arduino can be multifaceted, aiming to address various aspects related to energy efficiency, sustainability, and system robustness. Here are several key objectives that such a system may seek to achieve:

Optimize Energy Efficiency: Integrate renewable energy sources, such as solar or wind power, with the traditional AC system to maximize the utilization of clean and sustainable energy. Implement intelligent algorithms to dynamically balance and allocate power from different sources, considering factors like energy demand, availability of renewable resources, and overall system efficiency.

Reduce Carbon Footprint: Minimize reliance on conventional energy sources by incorporating renewable energy, thereby reducing greenhouse gas emissions and contributing to a more environmentally friendly power generation.

Enhance System Reliability and Resilience: Improve the reliability and robustness of the power supply by combining multiple sources, ensuring a more stable and resilient energy infrastructure.
Implement failover mechanisms and intelligent control to manage power distribution in the event of fluctuations or disruptions in any particular energy source.

Real-time Monitoring and Control: Develop a comprehensive monitoring system using Arduino to continuously track the performance of the hybrid system. Enable real-time control and adjustments based on data feedback, allowing the system to respond to changing conditions and optimize energy usage.

User Interaction and Control: Design a user-friendly interface, possibly through a graphical user interface (GUI), to allow end-users to monitor the system's operation, set preferences, and receive notifications. Provide users with control over the hybrid system, allowing them to make informed decisions about energy consumption and source prioritization.

Scalability and Adaptability: Design the system with scalability in mind, enabling easy integration of additional renewable sources or expansion of the system to accommodate growing energy demands.
Ensure adaptability to different environmental conditions and energy requirements, making the hybrid system suitable for diverse applications and settings.

Educational and Demonstration Purposes: Serve as an educational tool to demonstrate the feasibility and benefits of hybrid AC systems with Arduino control.

Foster awareness and understanding of sustainable energy practices by showcasing a practical application of renewable energy integration.

By addressing these objectives, a hybrid system with AC integration using Arduino can contribute to a more sustainable, efficient, and resilient energy infrastructure.

1.4 Project Report Organization

This project book is arranged into the following chapters:

Chapter 1 gives a brief introduction to the background of the project, objectives, and report organization.

Chapter 2 focuses on the various types and theoretical aspects of hybrid system scheme.

Chapter 3 focuses on the design of real-time based monitoring and efficient hybrid system with AC.

Chapter 4 concludes the overall discussion project and future recommendation are also presented in this chapter.

Chapter 5 focuses on the results of this proposed system.

Chapter 6 includes the advantages disadvantages limitations and conclusions etc.

Chapter 7 focuses on the limitation and Future scope of this proposed system.

Chapter 8 includes the conclusion about our proposed project.

CHAPTER 2

THEORETICAL ASPECTS

The electric power system, a vast and complex system, is managed through power system community. The network has been, is, and will be characterized by sharing varying renewable sources. The sharing in electricity generation at global scale is accomplished through an increase in renewable sources. The industrial advances and environmental concerns make the interconnection of renewable energy sources tendency toward the distribution network. Hybrid system are local power systems of different size, operating inside the distribution systems. Due to their ability to: (a) reduce environmental impact, reduce investment in power plant construction, equipment and cost, (b) increasing energy stable efficiency, (c) ride-through capability provided by energy storage, and (d) alleviate consequences of sudden grid outages on-grid are becoming popular. This current is then sent to an inverter. The solar inverter then converts the DC to Alternating Current (AC), thus making it power the electrical items. This electricity is then routed to the grid where it is supplied for day to day use. The grid tied inverter additionally regulates the amount and voltage of electricity fed to the household since all the power generated is mostly much more than a home needs or can handle.

Renewable energy sources like the wind, solar energy, and hydro are cost-effective in meeting their share of the energy requirement. As to power supply, the on-grid technology provides important opportunities in remote communities with improved local energy security. This technology is highly contributing in assuring more secure energy by reducing the need to import energy. By connecting renewable energy Hybrid system to the utility grid, no additional effort is needed for frequency regulation. The most relevant challenges in hybrid system consist of: stability, bidirectional power flows, modeling, low less inertia, the effect of load perturbation, and uncertainty. Application of each distributed generators (DGs) can cause more problems that it can solve. Hybrid system are small-scale energy grids, where renewable energy generation and storage technologies are integrated to provide adequate energy supply to cover regional demand.

2.1 Features of the on-grid power plant

1. It is the green power which brings no pollution the environment
2. Easy to install, as main part are only solar panels, inverters and accessories.
3. Lower the electricity cost a lot as solar panel under over 20 years warranty and of higher lifespan.
4. It is a perfect solution to the places where the grid is not available like Africa, south Asia and so on.

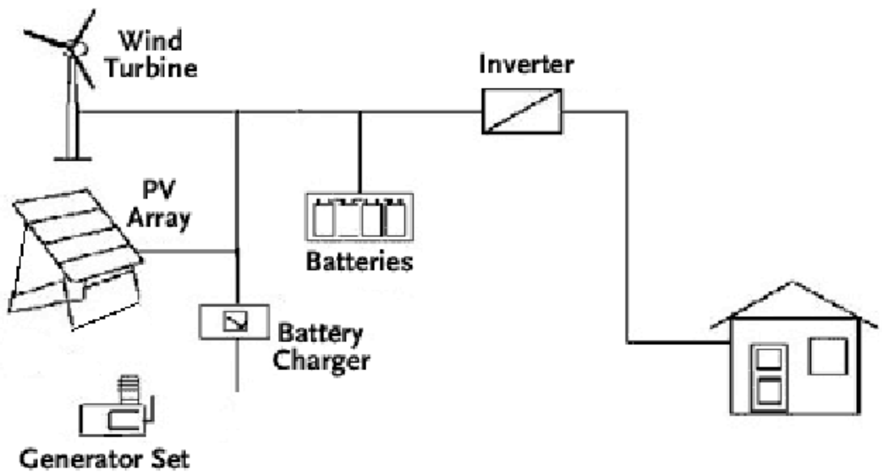

Figure 2.1: Hybrid System

2.2 Hybrid System

A hybrid system typically refers to a system that combines two or more different components or technologies to work together synergistically, often to achieve enhanced performance, efficiency, or versatility. Hybrid systems are prevalent in various fields, including energy, transportation, electronics, and more.

A hybrid power generation system refers to a setup that integrates multiple sources of power generation to produce electricity. The combination of different power generation technologies allows for increased efficiency, reliability, and flexibility in meeting energy demands. Hybrid power generation systems are often designed to harness both conventional and renewable energy sources, taking advantage of the strengths of each component. Here are some common components in a hybrid power generation system:

Renewable Energy Sources:

Solar Power: Photovoltaic panels convert sunlight into electricity.

Wind Power: Turbines generate electricity from the kinetic energy of the wind.

Hydropower: Electricity is produced by harnessing the energy of flowing water.

Conventional Power Sources: Internal Combustion Generators: Engines, often running on diesel or natural gas, generate electricity through combustion.

Gas Turbines: Combustion turbines convert fuel into electricity through a rotating turbine.

Micro turbines: Small-scale turbines that can run on various fuels to generate electricity.

Energy Storage Systems:

Batteries: Store excess energy generated during periods of low demand or high renewable energy production for use during peak demand or when renewable sources are unavailable.

Flywheels: High-speed rotating devices that store kinetic energy and convert it back into electricity when needed.

Intelligent Control System: Microcontrollers, programmable logic controllers (PLCs), or sophisticated control algorithms manage the operation of the various components. The control system optimizes the use of each power source based on factors such as energy demand, availability of renewable energy, and system efficiency.

Grid Connection (if applicable): Some hybrid power generation systems are connected to the electrical grid. Excess electricity generated can be fed back into the grid, and power can be drawn from the grid during periods of low energy production or high demand.

Load Management: The system dynamically balances and manages loads, directing power from the most suitable source based on current conditions. It may prioritize the use of renewable energy to minimize the reliance on conventional sources.

Monitoring and Diagnostics: Sensors continuously monitor system parameters, including energy production, storage levels, and equipment health. This data is used for diagnostics, maintenance planning, and performance optimization.

Adaptive Operation: The system adapts to changing conditions, adjusting its operation to variations in renewable energy availability, energy demand, or component failures.

User Interface: A user interface, such as a graphical user interface (GUI), allows users to monitor the system's performance, set preferences, and receive alerts. Users may have control over certain parameters to align the system with specific requirements.

By combining renewable and conventional energy sources with energy storage and intelligent control, hybrid power generation systems aim to provide a reliable, efficient, and sustainable solution to meet varying energy demands while reducing environmental impact. The specific components and configuration can vary based on the application and the availability of energy resources in a given location.

2.3 Differences between Hybrid and On-Grid system

On-grid and hybrid systems are two different types of solar power systems that are used for electricity generation. Here are the key differences between on-grid and hybrid system:

Table I: Difference between Hybrid and On-grid system

Topic	On-grid System	Hybrid System
Connection to the Grid:	Also known as a grid-tied or grid-connected system, it is directly connected to the electrical grid. It operates in synchronization with the grid and feeds excess electricity back into the grid.	A hybrid system combines solar panels with energy storage components like batteries. It can be connected to the grid (grid-tied) but also operates independently during grid outages, providing a degree of energy autonomy.
Energy Independence:	Typically, on-grid systems do not provide energy independence during grid outages. When the grid goes down, these systems are designed to shut down for safety reasons, and users don't have access to solar-generated power.	Offers a level of energy independence as it can continue to provide power during grid outages. This is particularly beneficial in areas with unreliable or intermittent grid access.

Usage of Excess Energy:	Excess energy generated by the solar panels can be fed back into the grid, and users may receive credits or compensation for the surplus electricity through net metering or feed-in tariffs.	Excess energy can be stored in batteries for later use rather than being fed back into the grid. This stored energy can be utilized during periods of low solar production or high demand.
Cost and Complexity:	Generally, on-grid systems are simpler and more cost-effective to install because they do not require energy storage components like batteries. The system relies on the grid as a virtual storage system.	Generally more complex and costly than on-grid systems due to the inclusion of energy storage components. However, the additional cost can be justified by the increased self-sufficiency and resilience during grid disruptions.

In summary, the main distinction lies in the ability of a hybrid system to operate independently during grid outages, providing energy resilience. On-grid systems, on the other hand, are primarily designed to interact with and rely on the electrical grid. The choice between on-grid and hybrid systems depends on factors such as energy independence goals, grid reliability, and the specific requirements of the user.

2.3.1 Base on Access to Electricity

Electricity Access with Off-Grid Solar:

With an off-grid solar system, it’s completely reliant on the sun and energy stored in batteries to power any home or business. If it opt for a solar system that is not tied to the electric grid and it do not have a generator, it will only have electricity at two points:

1. When the sun is shining and this solar system is producing electricity.
2. When it will pulling electricity previously generated by its solar system from a solar storage device, like batteries.

If there have not have batteries or a means to store its energy, it will have less or no electricity when it’s cloudy, and it will not have electricity at night.

Electricity Access with On-Grid Solar:

If anybody decide to install an on-grid solar system, he will always have access to electricity (unless the grid goes down), whether or not his solar system is producing or if he had batteries. If his system is not producing any electricity or not producing enough electricity to power the devices, lights, machines, etc. that he is using, he can pull energy from the utility grid to supplement it. This ensures he always have enough electricity for what his need.

2.3.2 Base on Excess Production

Excess Production with Off-Grid Solar:

Depending on the size of the system install, how much electricity anybody can use, and when he use that electricity, there will likely be times when his system is producing more electricity than you're using. What happens to this excess energy depends on the equipment that he install. Most off-grid solar systems are designed to produce a certain amount of "extra" electricity in the daytime, which is sent to batteries for storage. The energy stored in those batteries can then be accessed when the system is not producing, like at night or during cloudy weather. Depending on his energy goals, systems can be sized to produce enough excess electricity in the daytime to cover his entire energy usage around-the-clock. However, despite even the best and most accurate estimates, the weather is unpredictable. If you experience abnormally cloudy weather several days in a row, his system may not be able to produce enough electricity to charge the batteries and fulfill all his needs. While having extra batteries offers peace of mind and can provide a bank of stored electricity just in case this happens, they're also expensive. Purchasing more batteries than he need may be cost-prohibitive, depending on your budget.

Excess Production with On-Grid Solar:

Just like off-grid solar systems, many who choose to install an on-grid solar system want to cover 100% or nearly 100% of their energy usage. This can be achieved with on-grid systems as well. Depending on the time of day you use electricity, his solar system can produce excess energy. Instead of sending it to batteries as you would in an off-grid system, he can send it to the grid and you will be compensated for that electricity.

For many in the United States, they'll be compensated through something called net metering. Net metering is when the utility company compensates or credits his account for electricity generated by his solar system and sent to the grid. Then, whenever his need to draw energy off the grid, he will be drawing on those credits to get his electricity without racking up charges on his electricity bill. There are currently mandatory net metering rules for 39 states. 11 states are either transitioning or are currently implementing compensation methods other than net metering.

2.3.3 Base on Power outages

Power Outages with Off-Grid Systems:

Solar system is working independently from the power grid. If there's a bad storm or event that knocks out the power, solar system can continue operating. You won't notice changes in your service or access to electricity.

Power Outages with Grid-Tied Systems:

By connecting to the grid, anybody get access to electricity whenever he need it. However, he is also subject to some rules. If he have a grid-tied solar system and the grid goes down, he will not have electricity, unless he opt for a grid-tied solar system with battery backup. The shutdown of solar systems when the grid goes down is required by the Underwriters Laboratories (UL 1741) . This is for the safety of utility workers who are fixing the power lines. While this is a disadvantage of grid-tied systems over off-grid systems, if keeping things up-and-running during a power outage is important to him, then he may be interested in adding batteries to his grid-tied system.

2.3.4 Base on Electricity Bills

Electricity Bills with an Off-Grid System:

If the PV system is not tied to a grid, you won't receive an electric bill at all. However, even with no electric bill, off-grid systems are often more expensive because of the additional equipment like batteries that are needed to make it viable.

Electricity Bills with a Grid-Tied System:

If anybody opt for a grid-tied system, he could still see a few minimal charges on his electricity bill, even if his solar system provides 100% of your electricity. One type of charge he may continue to see is the service fee or delivery charge. This is the cost levied on customers for connecting their home or business to the grid. For many utilities, this fee is a flat rate that is not impacted by how much electricity he use. Another type of charge he can see is demand charges. Demand charges are typically levied on commercial properties and are the increased electric rate his pay for the power you use during a peak demand period. The peak demand period is typically the 15-minute period in which his business uses the most electricity. Because using a large amount of electricity at one time puts a strain on the grid, the utility will charge a higher rate for the electricity used during that period.

CHAPTER 3

SYSTEM DESIGN

3.1 Design Methodology

Hybrid systems with AC are by far the most common and widely used by homes and businesses. These systems do not need batteries and use either solar inverters or micro-inverters and are connected to the public electricity grid. Any excess solar power that generate is exported to the electricity grid and usually get paid a feed-in-tariff or credits for the energy you export. Unlike hybrid systems, hybrid system with AC are not able to function or generate electricity during a blackout due to safety reasons. Since blackouts usually occur when the electricity grid is damaged;

3.2 Block Diagram

This system works on two types of power generation. One is wind system another is solar system. In this block diagram you see separated sours for each system of solar and wind turbine.

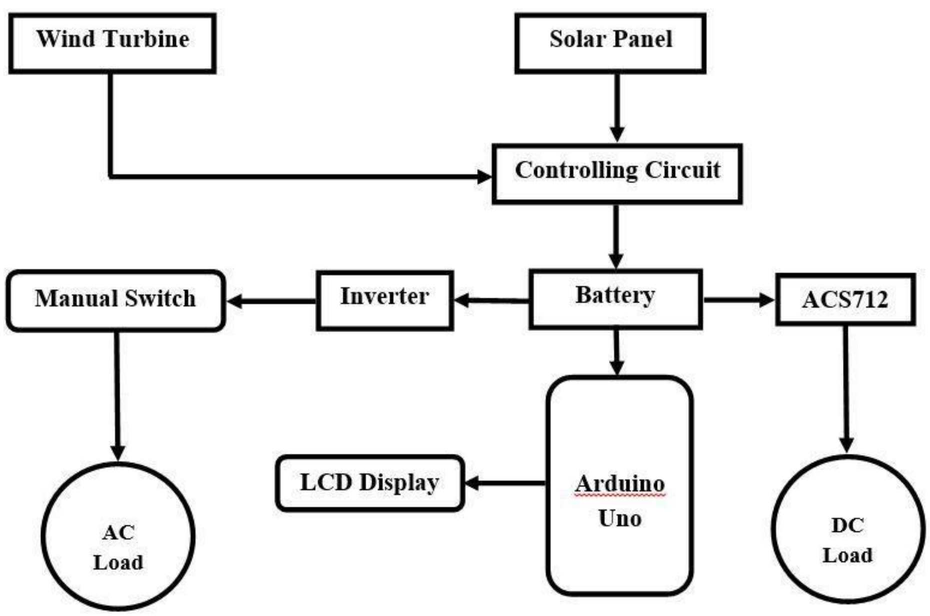

Figure 3.1: Block diagram of the proposed system

In this system Arduino Uno will monitoring this total system as per our command that we inserted here. LCD Display will show the readings of this system like Battery voltage, Solar voltage, Wind voltage, consumed current value by using our DC Loads. To operate our AC load we need to invert our DC voltage to AC voltage. We inserted here manual switch to control our loads as per our required. Battery is used here to store the generated voltage from this wind and solar system and operate microcontrollers.

3.3 Circuit diagram

In this circuit diagram we use an Arduino Uno to control this system automatically. We used here different equipments such as Arduino Uno, LCD, ACS712 and other instruments also. Basically we make the circuit design using Porteous simulation software. In this system we measure the voltage value of both side using Arduino program and this voltage value will be same as actual value which is measured by multi-meter output.

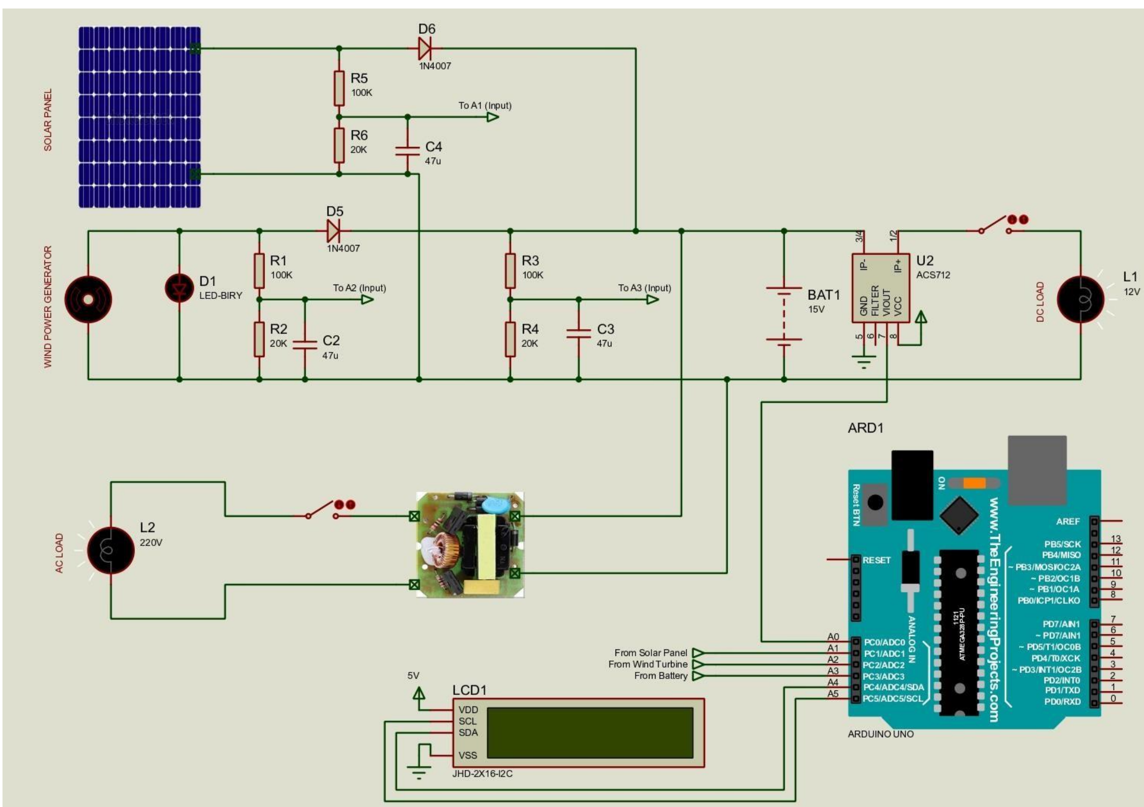

Figure 3.2: Complete circuit diagram

Here Arduino will play the main role as a controller but there have another two charge controller which is used to get signal from filed side. Here ACS712 is used to measure the consumed current by load. Controlling circuit will send data to Arduino about battery voltage, solar voltage and wind voltage. LCD Display will show the readings of this system like Battery voltage, Solar voltage, Wind voltage, consumed current value by using our DC Loads. To operate our AC load we need to invert our DC voltage to AC voltage. We inserted here manual switch to control our loads as per our required. Battery is used here to store the generated voltage from this wind and solar system and operate microcontrollers.

Diode: A diode is a two-terminal electronic component that conducts current primarily in one direction (asymmetric conductance); it has low (ideally zero) resistance in one direction, and high (ideally infinite) resistance in the other. A diode vacuum tube or thermionic diode is a vacuum tube with two electrodes, a heated cathode and a plate, in which electrons can flow in only one direction, from cathode to plate. A semiconductor diode, the most commonly used type today, is a crystalline piece of semiconductor material with a p–n junction connected to two electrical terminals. Semiconductor diodes were the first semiconductor electronic devices.

ACS712: In electrical engineering, current sensing device ACS712 is any one of several techniques used to measure electric current. The measurement of current ranges from picoamps to tens of thousands of amperes. The selection of a current sensing method depends on requirements such as magnitude, accuracy, bandwidth, robustness, cost, isolation or size. The current value may be directly displayed by an instrument, or converted to digital form for use by a monitoring or control system.

3.4 Hardware Overview

Here, we try to design a Hybrid system with AC. In this system, we can operate two types of loads, one is AC Load and another is DC Load.

Figure 3.3: Full over view of proposed system

We used here a solar panel to provide DC voltage to the system. Solar panel will generate DC Voltage from sun ray and operate the loads. Wind system also generate voltage from the rotation of DC motor. Generated voltage will be stored in our battery section and then it will use for different operations. Here DC to AC Inverter is used to make sure the AC output from DC battery voltage to operate AC Loads.

CHAPTER 4

HARDWARE AND SOFTWARE IMPLEMENTATION

4.1 Operation and working Procedure

Here, we try to design a Hybrid system with AC. In this system, there 2 types of loads one is AC Load Side and another is DC Load Side. We used here a solar panel to provide DC voltage to the system.

Figure 4.1: AC and DC load in operation of proposed system

Solar panel will generate DC Voltage from sun ray and operate the loads. Generated voltage will be stored in our battery section and then it will use for different operations. To recharge our battery, we can generate power from wind system also. In this part air flow will help the wind fan to rotate regularly and this rotation will be converted to DC Voltage. Here DC to AC Inverter is used to make sure the AC output from DC battery voltage. That capable to operate the AC loads. In this way, our all AC and DC loads will be running.

4.2 Required Components

We use here different types of instrument to make this project. Some of the instrument is listed here and show the list in bellow sequent. Basically here main program is arduino uno and controlling circuit will work as controller. Solar panel will provide the dc voltage to our system. Wind system will generate voltage from the air pressure.

Table II: Used instruments list

S.N.	Name & Description	Qty.
1.	Aduino uno	1
2.	Solar panel	2
3.	Buck converter	1
4.	Current Sensor	1
5.	LCD Display	1
6.	Battery Holder	1
7.	Battery (3.7V)	4
8.	Inverter Circuit	1
9.	PVC Board	3
10.	Connecting Wire	Needed
11.		

4.3 Arduino Uno

The Arduino Uno is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino.cc. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 digital I/O pins (six capable of PWM output), 6 analog I/O pins, and is programmable with the Arduino IDE (Integrated Development Environment), via a type B USB cable. It can be powered by the USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts. It is similar to the Arduino Nano and Leonardo. The hardware reference design is distributed under a Creative Commons Attribution Share-Alike 2.5 license and is available on the Arduino website. Layout and production files for some versions of the hardware are also available. The word "uno" means "one" in Italian and was chosen to mark the initial release of Arduino Software. The Uno board is the first in a series of USB-based Arduino boards; it and version 1.0 of the Arduino IDE were the reference versions of Arduino, which have now evolved to newer releases. The ATmega328 on the board comes preprogrammed with a bootloader that allows uploading new code to it without the use of an external hardware programmer.

Figure 4.2: Arduino Uno

While the Uno communicates using the original STK500 protocol, it differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it uses the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.

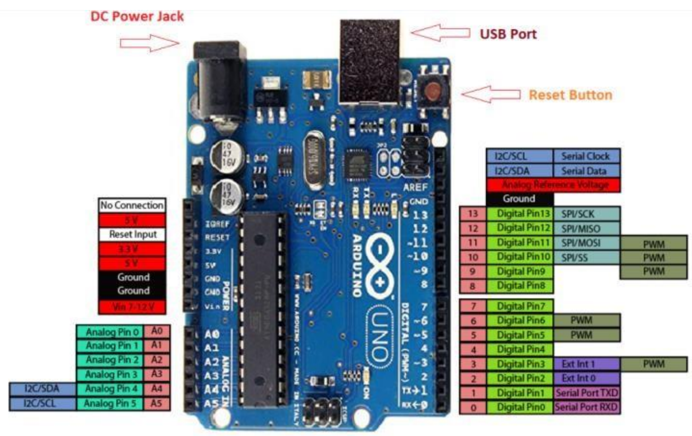

Figure 4.3: Arduino Pinout

The Arduino project started at the Interaction Design Institute Ivrea (IDII) in Ivrea, Italy. At that time, the students used a BASIC Stamp microcontroller, at a cost that was a considerable expense for many students. In 2003, Hernando Barragán created the development platform Wiring as a Master's thesis project at IDII, under the supervision of Massimo Banzi and Casey Reas, who are known for work on the Processing language. The project goal was to create simple, low-cost tools for creating digital projects by non-engineers. The Wiring platform consisted of a printed circuit board (PCB) with an ATmega168 microcontroller, an IDE based on Processing, and library functions to easily program the microcontroller. In 2003, Massimo Banzi, with David Mellis, another IDII student, and David Cuartielles, added support for the cheaper ATmega8 microcontroller to Wiring. But instead of continuing the work on Wiring, they forked the project and renamed it *Arduino*. Early arduino boards used the FTDI USB-to-serial driver chip and an ATmega168. The Uno differed from all preceding boards by featuring the ATmega328P microcontroller and an ATmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.

4.4 Solar Panel

Solar panels are those devices which are used to absorb the sun's rays and convert them into electricity or heat.

Figure 4.4: Solar panel

A solar panel is actually a collection of solar (or photovoltaic) cells, which can be used to generate electricity through photovoltaic effect. These cells are arranged in a grid-like pattern on the surface of solar panels. Thus, it may also be described as a set of photovoltaic modules, mounted on a structure supporting it. A photovoltaic (PV) module is a packaged and connected assembly of 6×10 solar cells. When it comes to wear-and-tear, these panels are very hardy. Solar panels wear out extremely slow. In a year, their effectiveness decreases only about one to two per. Installation of solar panels in homes helps in combating the harmful emissions of greenhouse gases and thus helps reduce global warming. Solar panels do not lead to any form of pollution and are clean. They also decrease our reliance on fossil fuels (which are limited) and traditional power sources. These days, solar panels are used in wide-ranging electronic equipments like calculators, which work as long as sunlight is available. However, the only major drawback of solar panels is that they are quite costly. Also, solar panels are installed outdoors as they need sunlight to get charged.

4.5 Current Sensor

The protection of the transformer against over current is concerned with the detection and measurement of fault, where the measurement can be dangerous and indeed impossible to measure if the actual load and fault currents are very large. A professional way of avoiding these difficulties is to use the current sensor. Therefore, in the block diagram, current transformer is used to measure the load current. The current sensor ACS712 was used because the current sensor ICs provides economical and precise solution for AC or DC current sensing in industrial, automotive, commercial, and communication systems.

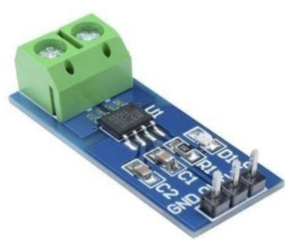

Figure 4.5: ACS712 current sensor

The device can be used load detection and management, power supplies and over current fault protection. The current sensor is capable of measuring up to 3A.The monitored current values are displayed on the LCD display and as soon the voltage transformer is overloaded the current transformer sends the information through the ADC and the microcontroller energizes the relay, thereby protecting the transformer.

4.6 LCD Display

This is a 20 character x 4 line blue background Super Twisted Nematic (STN) LCD with built-in HD44780 equivalent controller (also known as alphanumeric displays). Interfacing is simplified with 4 bit or 8 bit communications and programming code is widely available for many different controllers and systems.

Figure 4.6: LCD

Features:

- High contrast STN 20×4 character LCD
- White text on blue background
- Single +5.0V supply operation
- LED backlight
- 5x8 dot characters
- HD44780 equivalent controller
- 4 or 8 bit interface

4.7 Battery 3.7V

The 3.7v lithium battery is a lithium battery with a nominal voltage of 3.7v and a full-charge voltage of 4.2v. Its capacity ranges from several hundred to several thousand mAh.

This Standard 18650 3800mAh 3.7v Rechargeable Li-Ion Battery is a single cell compact and powerful battery cell with 3800 mAh capacity. This Li-ion battery is very convenient to install in your project where 3.7 Volt with high capacity is needed.

For the model LP963450 (3.7V/1800mAh), it is a single cell, and your following understanding is correct. For the battery pack, it is consisting of the cells connected in series or in parallel.

Voltage: 3.7 V. Current Rating: 3000mAh. Charging environment temperature range: 32° to 113° F. In use temperature range: -4° to 140° F.

Figure 4.7: Battery 3.7V

4.8 Buck Converter

A buck converter or step-down converter is a DC-to-DC converter which decreases voltage, while increasing current, from its input (supply) to its output (load). It is a class of switched-mode power supply. Switching converters (such as buck converters) provide much greater power efficiency as DC-to-DC converters than linear regulators, which are simpler circuits that dissipate power as heat, but do not step up output current.[1] The efficiency of buck converters can be very high, often over 90%, making them useful for tasks such as converting a computer's main supply voltage, which is usually 12 V, down to lower voltages needed by USB, DRAM and the CPU, which are usually 5, 3.3 or 1.8 V. Buck converters typically contain at least two semiconductors (a diode and a transistor, although modern buck converters frequently replace the diode with a second transistor used for synchronous rectification) and at least one energy storage element (a capacitor, inductor, or the two in combination). To reduce voltage ripple, filters made of capacitors (sometimes in combination with inductors) are normally added to such a converter's output (load-side filter) and input (supply-side filter). Its name derives from the inductor that “bucks” or opposes the supply voltage.

Figure 4.8: Buck Converter

Buck converters typically operate with a switching frequency range from 100 kHz to a few MHz. A higher switching frequency allows for use of smaller inductors and capacitors, but also increases lost efficiency to more frequent transistor switching.

4.9 Inverter Circuit

A power inverter, inverter or invertor is a power electronic device or circuitry that changes direct current (DC) to alternating current (AC). The resulting AC frequency obtained depends on the particular device employed. Inverters do the opposite of rectifiers which were originally large electromechanical devices converting AC to DC. The input voltage, output voltage and frequency, and overall power handling depend on the design of the specific device or circuitry. The inverter does not produce any power; the power is provided by the DC source. A power inverter can be entirely electronic or maybe a combination of mechanical effects (such as a rotary apparatus) and electronic circuitry. Static inverters do not use moving parts in the conversion process.

Power inverters are primarily used in electrical power applications where high currents and voltages are present; circuits that perform the same function for electronic signals, which usually have very low currents and voltages, are called oscillators. Circuits that perform the opposite function, converting AC to DC, are called rectifiers.

Figure 4.9: Inverter Circuit

4.10 DC Motor

A DC motor is an electrical motor that uses direct current (DC) to produce mechanical force. The most common types rely on magnetic forces produced by currents in the coils. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic, to periodically change the direction of current in part of the motor.

Figure 4.10: DC Motor

DC motors were the first form of motors widely used, as they could be powered from existing direct-current lighting power distribution systems. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings. Small DC motors are used in tools, toys, and appliances. The universal motor, a lightweight brushed motor used for portable power tools and appliances can operate on direct current and alternating current. Larger DC motors are currently used in propulsion of electric vehicles, elevator and hoists, and in drives for steel rolling mills. The advent of power electronics has made replacement of DC motors with AC motors possible in many applications.

4.11 Software Implementation

Here we describe the software which is used here to design and upgrade this system. We use two software like Proteus 8 Professional and Arduino IDE.

4.11.1 Proteus 8 Professional

Want to test your circuit diagram? Bread boarding it can be a good option, but it is easy to get confused if your circuit is big. we can try creating a PCB and testing on it, but is a very time-consuming task and even takes a lot of effort. Simulating it is the best idea. we can use Proteus 8 Professional. Proteus 8 Professional is a software which can be used to draw schematics, PCB layout, code and even simulate the schematic. It is developed by Labcenter Electronic Ltd. Designing PCBs are easy using Proteus.

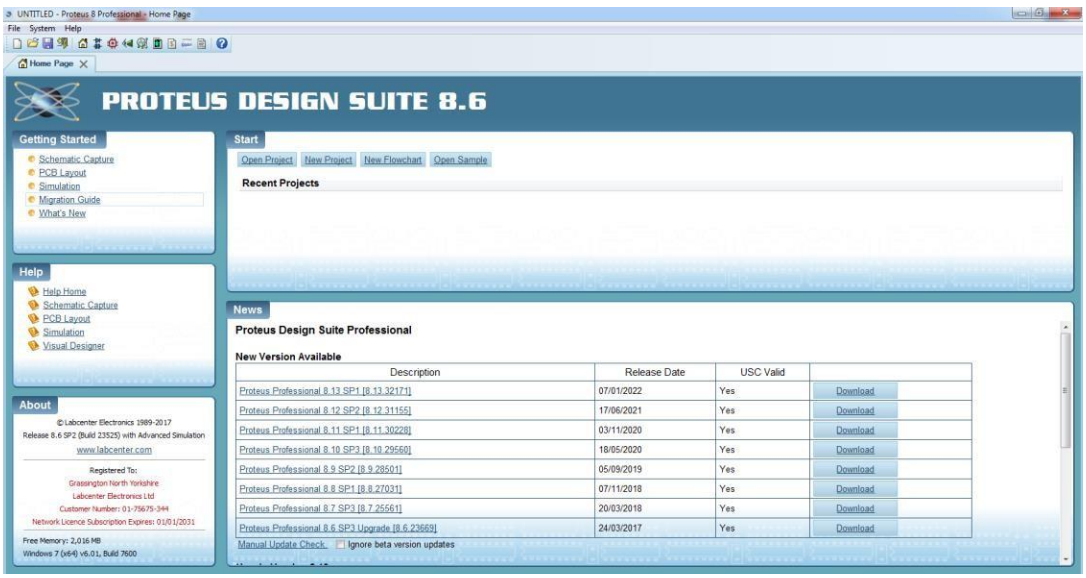

Figure 4.11: Proteus 8 Professional Software

We can make your own design or let Proteus do that for you. Making your own design is simple, you just have to place the components used in the schematic and draw traces over them. Don't worry about violating any design rules because it automatically detects design rule (DRC) errors. We can also let Proteus do the work for you. We can place the components on their respective places and select the "auto route" option. This will automatically draw multiple variations of traces and selects the best one. There is also an

"Auto placer" option present; this option needs you to specify the board dimensions by drawing the shape and size of the board so that, it can place the components within the board boundaries. So, all you have to do is to make the schematic.

Circuit ready for testing? We can test it using Proteus's simulation feature. Many of the components in Proteus can be simulated. There are two options for simulating: Run simulator and advance frame by frame. The "Run simulator" option simulates the circuit in a normal speed (If the circuit is not heavy). "Advance frame by frame" option advances to next frame and waits till you click this button for the next time. This can be useful for debugging digital circuits.

We can also simulate microcontrollers. The microcontrollers which can be simulated include PIC24, dsPIC33, 8051, Arduino, ARM7 based microcontrollers. We can download the compilers for Proteus or use different compiler and dump the hex files in the microcontroller in Proteus. We can even interact in real-time with the simulation using switches, resistors, LDRs, etc. There are even virtual voltmeter, ammeter, oscilloscope, logic analyzer, etc.

Software Implementation is done by means of Arduino software. Programming of Arduino and Interfacing of sensors with Arduino are the main part of software implementation. The programming part is done by using the “C” language. The hardware circuit gets initialized as soon as the power supply is given to it. LCD display is interfaced with the Arduino so that it displays the parameter values like voltage, current, and temperature. When any problem occurs in the transformer it will be displayed on the LCD (16×2) display.

4.11.2 Arduino IDE

The Arduino Integrated Development Environment **(IDE)** is a cross-platform application (for Windows, macOS, Linux) that is written in functions from C and C++. It is used to write and upload programs to Arduino compatible boards, but also, with the help of third-party cores, other vendor development boards.

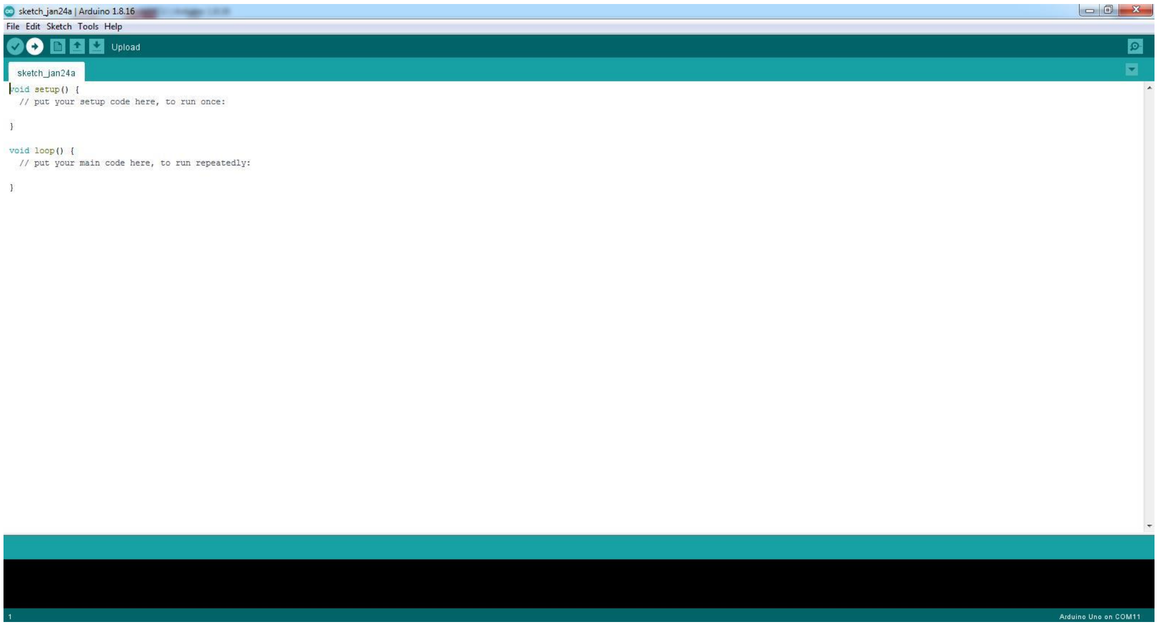

Figure 4.12: Arduino IDE Software

The source code for the IDE is released under the GNU General Public License, version 2. The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub *main()* into an executable cyclic executive program with the GNU toolchain, also included with the IDE distribution. The Arduino IDE employs the program *avrdude* to convert the executable code into a text file in hexadecimal encoding that is loaded into the Arduino board by a loader program in the board's firmware. By default, avrdude is used as the uploading tool to flash the user code onto official Arduino boards.

CHAPTER 5

RESULTS AND DISCUSSIONS

5.1 Discussion

In this hybrid system with AC, we try to make voltage conversion from DC to AC. The main reason of this system is to operate our all load without any delay or laggings. If there have no AC supply from our grid line at that time we invert our DC voltage to AC Voltage for operating our AC loads. A hybrid power generation system is a versatile and innovative approach that combines multiple sources of power generation to create a more resilient, efficient, and sustainable energy infrastructure. This system addresses the challenges associated with single-source power generation and leverages the strengths of different technologies to meet varying energy demands. Here's a discussion on some key aspects and benefits of hybrid power generation systems. One of the primary advantages of a hybrid power generation system is the ability to diversify energy sources. By integrating renewable sources such as solar, wind, or hydro with conventional sources like diesel generators or gas turbines, the system can harness clean energy while maintaining reliability. Hybrid systems enhance the reliability of power generation by providing a backup or alternative source during fluctuations or failures in any single component. Energy storage systems, often included in hybrid setups, contribute to grid stability and act as a buffer during intermittent renewable energy production.

5.2 Results

Our system is working here very smoothly and properly. Now its time to show the operational output of ore hybrid system. In this part we will measure solar voltage, wind voltage, Battery voltage, consumed current value by using DC Load. All the values will be displayed in LCD. We can control our AC and DC Loads by using manual switches and we can make sure power supply connection by using a separated switch.

In bellow, we included here the results or operational output for different operation.

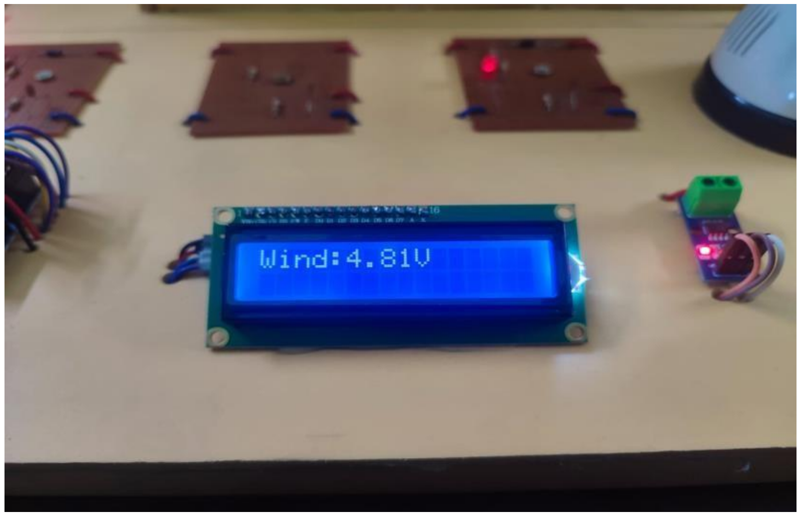

Figure 5.1: Wind Voltage

This is the output from wind to system. To make sure the charging of battery from wind transmission line we used here a DC generator.

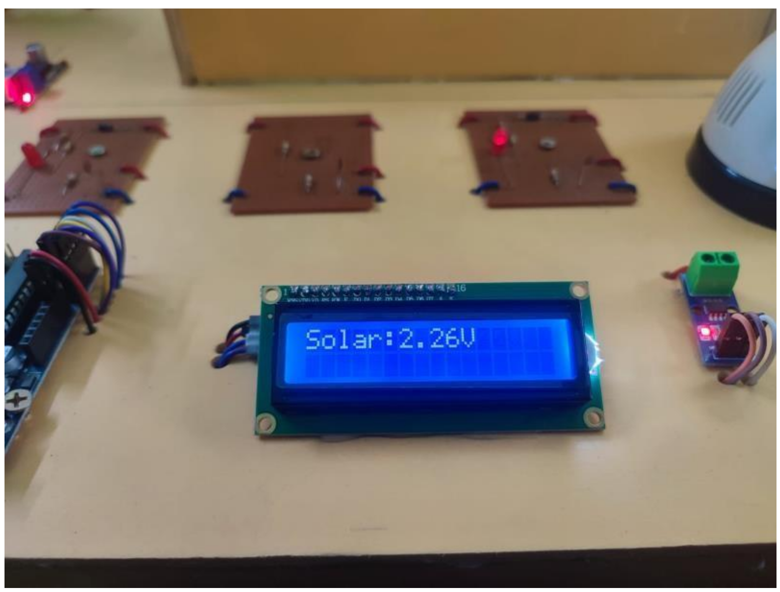

Figure 5.2: Solar Voltage

This is the output from solar panel in low sunlight condition. When we will make sure proper sunlight at that moment this value will be increase automatically be the force of sunlight. This is the exact value of solar panel output voltage.

Figure 5.3: Battery Voltage

We show here the output of battery voltage. This battery will be charged from solar panel and grid line. Out total operating system will be operated by using this battery source.

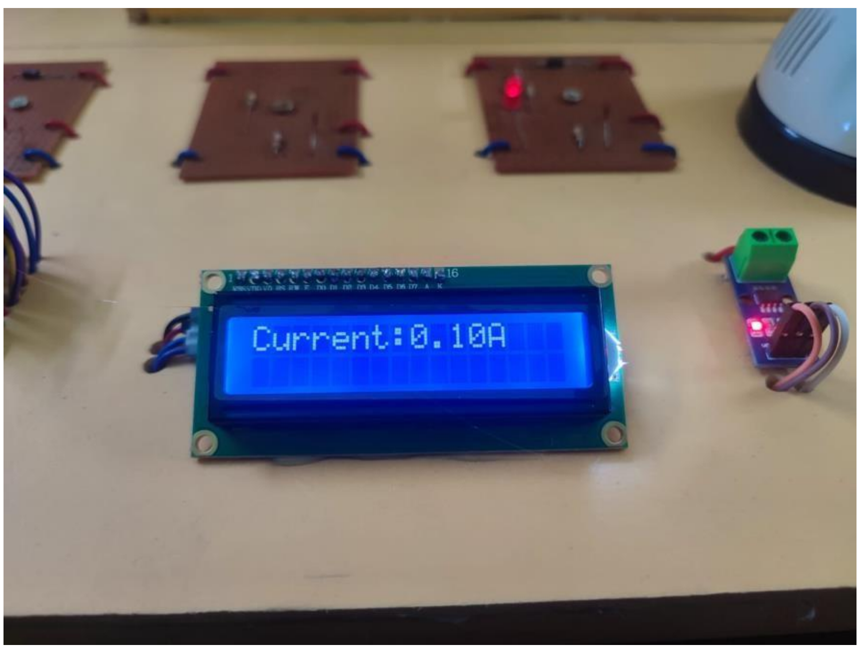

Figure 5.4: Current Value (Load ON)

We measure here the amperage of our DC load. This is the output when the load is ON.

CHAPTER 6

ADVANTAGES AND DISADVANTAGES

Hybrid System with AC or photovoltaic wind hybrid system is a system that can be integrated into two or more renewable sources of energy. Those systems are integrated to provide electricity or heat, or both, to supply the demand, and taking advantage of the availability of solar and wind energy, in places where these two sources of renewable energies are complementing to each other. Interested readers are advised to consult reference on the subject. The wind energy depends on the conditions of the wind and ambient conditions, the wind turbine is recommended where average annual wind speeds are higher than 6.5m/s at a height of 50m. On the other hand, photovoltaic energy has been one of the renewable energy sources with rapid technological growth. It has been reported that its annual production of solar panels grew tenfold from 1990 to 2003 (50 MW to 500 MW), and is in constant growth.

6.1 Benefits of Hybrid system

Zero Electricity Bills – though the solar power system is connected to the Wind turbine, and both system will generate voltage from natural power sours. That's why there have no need to pay any electricity bill to any authority.

Easy maintenance – The Hybrid system has the least number of parts along with simple installation. The elimination of batteries makes the maintenance quite easy.

Passive income generation – With a connection to the grid, the consumer can charge for the surplus electricity he has generated. It not only eliminates your electricity bills but also avails the cost benefits for the excess electricity generated.

Solar power has several benefits which notably include a reduction in electricity cost and usage. However, there are other benefits that depend on the type of system you choose.

6.2 Advantages

- In rainy and winter season the amount of solar radiation is not sufficient than in this season energy is fulfilled by wind energy system.
- Due to variation in weather condition when there is lack of wind energy than the power is supplied by the solar panels.
- Low operating cost and maintenance cost makes it economical.
- Used in any location whether it is remote area or populated area.
- Highly efficient power generation
- Solar- and wind-powered sites benefits the environment as it will reduce the carbon and other harmful emission is about 90% in environments.

6.3 Disadvantages

- Electrical energy needs to be stored in battery banks thus requiring more space and maintenance.
- Resynchronization with the utility grid is difficult.
- Hybrid System with AC protection is one of the most important challenges facing the implementation of this system.
- Issues such as standby charges and net metering may pose obstacles for micro-grid.

CHAPTER 7

LIMITATIONS AND FUTURE SCOP

The function of the photovoltaic solar panel is simple; solar panels receive solar radiation form of light and thus generate a potential difference at its ends in the form of continuous current. These panels are normally connected in parallel or series depending on the power and load requirements. It should be noted that a hybrid system such as solar/wind hybrid must have load/charge controller which controls the wind turbine and solar panel at the same time and allows the conversion and transformation of wind and solar energies into electrical energy and consequently, stores this electrical energy in the batteries bank. It should be also noted that the driver of the hybrid Wind/Solar is the most important part in the out-of-network system, due to the control that allows the operation of all the hybrid system.

7.1 Limitations

- Here our Battery storage are so much limited which is not able to give backup for long time in this system.
- The output of our inverter circuit can operate maximum 6w AC load.
- In this system we can charge our battery as per our requirement and generated voltage output of solar and wind system.

7.2 Future Scope

- We use here only one solar panel, we can add more and more solar panel to increase our serving area.
- Basically it's a simple design, we can improve the system using IOT operation system to control proposed system from remote area.
- We can make the system with grid connected system to improve our hybrid system.

CHAPTER 8

CONCLUSION

Hybrid power generation system that combines wind and solar energy sources presents a compelling solution for addressing the challenges associated with single-source power generation. The synergistic integration of wind and solar components provides a more reliable, sustainable, and efficient energy generation platform. This paper is intended to discuss the construction and implementation of a system for the measurement of electrical power parameters such as amperage and voltage of the hybrid system; photovoltaic solar-wind, to evaluate and analyze the system performance. With the rapid increase in population and economic development, the problems of the energy crisis and global warming effects are today a cause for increasing concern. The utilization of renewable energy resources is the key solution to these problems. Solar energy is one of the primary sources of clean, abundant and inexhaustible energy that not only provides alternative energy resources, but also improves environmental pollution. Solar tracking is the most appropriate technology to enhance the electricity production of a PV system. To achieve a high degree of tracking accuracy, several approaches have been widely investigated. Generally, they can be classified as either open-loop tracking types based on solar movement mathematical models or closed-loop tracking types using sensor-based feedback controllers.

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APPENDIX

A. Programming Code:

```
#include <ACS712.h>
#include <Wire.h>
#include <SoftwareSerial.h>
#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x27,16,2);

ACS712 sensor(ACS712_05B, A0); //Select ACS712 sensor
#define Current_sensor A0 //The sensor analog input pin

constintgridPin = A1;
constintbatteryPin = A2;
constintsolarPin = A3;


float i;
float Vb1=0;
float Vb2=0;
float Vb3=0;
float current;
float count=0;


void setup() {
lcd.init();
lcd.backlight();
Serial.begin(9600);

lcd.setCursor(0, 0);
lcd.print("   Welcome to      ");
lcd.setCursor(0, 1);
lcd.print("ON Grid PV System");
delay(2000);
lcd.clear();

pinMode(A0, INPUT);
pinMode(gridPin, INPUT);
pinMode(batteryPin, INPUT);
pinMode(solarPin, INPUT);

pinMode(12, OUTPUT);
pinMode(13, OUTPUT);

digitalWrite(12, LOW);
digitalWrite(13, LOW); }
```

```
void loop()
{

Vb1 = (analogRead (A1)/34.10);    // Grid Voltage
Vb2 = (analogRead (A2)/34.10);    // Battery voltage
Vb3 = (analogRead (A3)/34.10);      // Solar  Voltage
i = sensor.getCurrentDC();      // Current Measurment

   if (Vb1>10)
{
digitalWrite(12, LOW);
digitalWrite(13, LOW);
  }

  if (Vb1<10)
{
digitalWrite(12, HIGH);
digitalWrite(13, HIGH);
  }

lcd.clear();
lcd.setCursor(0, 0);
lcd.print("Grid:");
lcd.print(Vb1);
lcd.print("V");
delay(1000);

lcd.clear();
lcd.setCursor(0, 0);
lcd.print("Battery:");
lcd.print(Vb2);
lcd.print("V");
delay(1000);

lcd.clear();
lcd.setCursor(0, 0);
lcd.print("Solar:");
lcd.print(Vb3);
lcd.print("V");
delay(1000);

lcd.clear();
lcd.setCursor(0, 0);
lcd.print("Current:");
lcd.print(i);
lcd.print("A");
delay(1000);
}
```