Solar and Wind Hybrid Power Generation

[1]K.Bharath, Student of IV-I B.Tech, Mechanical Engineering , G. Pullaiah College of Engineering and Technology, Nandikotkur road, Kurnool, Andhra Pradesh

[2]M. Johnson, M.E (Ph.D), Assistant Professor, Department of Mechanical Engineering, G. Pullaiah College of Engineering and Technology, Nandikotkur road, Kurnool, Andhra Pradesh

[3]U. Revanth, Student of IV-I B.Tech, Mechanical engineering, G. Pullaiah College of Engineering and Technology, Nandikotkur Road, Kurnool, Andhra Pradesh

[4]M. Prem Kumar, Student of IV-I B.Tech, Department of Mechanical Engineering, G. Pullaiah College of Engineering and Technology, Nandikotkur Road, Kurnool, Andhra Pradesh

[5]Shaik fayaz ur rehaman, Student of IV-I B.Tech, , Department of Mechanical Engineering, G. Pullaiah College of Engineering and Technology, Nandikotkur Road, Kurnool, Andhra Pradesh

[6]G. Mallikarjuna, Student of IV-I B.Tech, Mechanical engineering, G. Pullaiah College of Engineering and Technology, Nandikotkur Road, Kurnool, Andhra Pradesh

Abstract:

Since the connection is not supported by the major players and is not economically viable, it is now not possible to reach the rural population that is not electrified by extending the grid. Furthermore, traditional energy solutions like fuel genet-based systems are gradually being removed from the agendas for rural development due to the rising costs of oil and the intolerable effects this energy source has on both consumers and the environment. "HYBRID POWER GENERATION USING SOLAR AND WIND ENERGY" is a solution to this issue. The most effective way to provide "high quality" power has been found to be through hybrid systems. The creation of hybrid power production systems, which integrate several renewable technologies, is a result of the growing demand for sustainable, clean, and renewable energy sources.

This project introduces a Solar and Wind Hybrid Power Generation System, which uses wind and solar energy to generate electricity continuously. The system produces electricity by combining solar photovoltaic (PV) panels with a wind turbine, guaranteeing a steady supply of power even in the face of variable weather. Solar panels produce their most when there is an

abundance of sunlight, while the wind turbine makes up for this during overcast or nocturnal conditions, increasing the system's overall stability and efficiency. Charge controllers are used to control the generated power, which is then stored in a battery bank that provides energy to the load during periods of low generation. This hybrid strategy lowers environmental pollution, increases energy reliability, and lessens reliance on fossil fuels. The study shows that integrating renewable energy for small-scale applications, distant area power delivery, and rural electrification is feasible.

Index terms: battery, inverter, LM317 regulator, solar panel, dc motor, boost converter, solar charge controller, and ac load

1. Introduction:

Many people are searching for sustainable energy solutions in order to protect the planet for next generations, as worries about global warming and the depletion of fossil fuel supplies grow. Wind and photovoltaic energy have the greatest potential to meet our energy needs, except from hydropower. When used alone, wind energy may provide significant amounts of electricity, but its availability is quite erratic—it can appear one minute and disappear the next.

Similar to this, solar energy is there all day long, but the amount of solar irradiation varies depending on the sun's strength and the erratic shadows created by trees, birds, clouds, and other objects. The intermittent nature of wind and photovoltaic systems, which renders them unreliable, is their shared intrinsic disadvantage. However, the efficiency and dependability of the system's power transfer can be greatly increased by merging these two intermittent sources and adding maximum power point tracking (MPPT) algorithms. The other energy source can make up the shortfall when one is not accessible or cannot adequately supply the demands of the load. Numerous MPPT-controlled hybrid wind/photovoltaic power systems have been proposed and explored in the literature. To carry out the MPPT control for each of the renewable energy power sources, the majority of systems in the literature use a different DC/DC boost converter coupled in parallel in the rectifier step. In order to integrate the sources from the DC-end and still achieve MPPT for each renewable source, a more straightforward multi-input structure has been proposed. The buck and buck-boost converters are combined in the structure that has been suggested. To eliminate the high frequency current harmonics pumped into wind turbine generators, the methods described in the literature need passive input filters. The generator's lifespan is shortened and power loss from heating is increased when the current has harmonic content.

For hybrid wind/solar energy systems, a different multi-input rectifier structure is suggested in this research. Energy demand is rising quickly in the modern world as a result of population growth, urbanization, and industrialization. Conventional energy sources like natural gas, coal, and oil are running out and seriously polluting the environment. As a result, renewable energy sources are becoming more and more significant worldwide. The most promising of these are wind and solar energy. Both have drawbacks, too, as wind energy is dependent on wind speed while solar energy is dependent on the amount of sunlight. Both are used in a solar-wind hybrid system to provide a more dependable, consistent, and effective power source.

2. Solar Working Principle:

Every gadget we use on a daily basis, including computers, cell phones, induction cookers, vacuum cleaners, and washing machines, needs an electric power source. Therefore, as technology advances, more electrical and electronic appliances are being used, which raises the demand for power. As a result, several methods for producing electric power are employed to satisfy the load requirement. Renewable energy sources like solar, wind, etc. are being preferred for power generation in recent years in order to prevent pollution and preserve non-renewable energy resources like coal, petroleum, etc. Hybrid power systems, which combine renewable energy sources, can also be utilized to generate electricity.

In this essay, we will address the operation of a solar-wind hybrid system as a specific situation. Small wind turbine generators and solar panels are used in solar and wind hybrid power systems to produce electricity. These solar-wind hybrid systems typically have limited capacities. Solar wind hybrid systems typically have power generation capacity between 1 kW and 10 kW. We should be aware of solar power generation systems and wind-power generation systems before briefly describing the solar and wind hybrid power system.

2.1. Photovoltaic cells in the sun Operational:

To comprehend how the solar panels transform solar energy into electrical energy, we also need to grasp how the solar cells function.

The devices that use the photovoltaic effect to transform solar energy into electrical energy are called solar cells or solar photovoltaic cells. Numerous real-time applications, including remote telecommunication systems, street lighting systems, railway signaling systems, and home lighting systems, rely on these cells. A P-type silicon layer is positioned in contact with an N-type silicon layer to form a solar photovoltaic cell. From the N-type material to the P-type material, the electrons disperse. The N-type material has more electrons than the P-type material, which has holes that take electrons. Thus, these electrons in the N-type material change from N-type to P-type under the impact of solar radiation.

The P-N junction is the result of these electrons and holes combining. This combination produces an electric field by creating a charge on either side of the P-N junction. A diode-like structure that facilitates the flow of charge is created as a result of this electric field generation. This is known as drift current, and it balances the diffusion of electrons and holes. This drift current, also known as the depletion zone or space charge region, happens where there aren't enough mobile charge carriers. Therefore, these solar photovoltaic cells function similarly to reverse bias diodes at night or in the dark.

2.2. **Objectives**

• To create a hybrid renewable energy system that combines wind and sun energy.

• To make up for the intermittent nature of individual sources in order to improve energy reliability.

• To provide electricity for off-grid or small-scale uses, such electrifying rural areas.

• To lessen carbon emissions and reliance on fossil fuels.

3. Working of Wind Power System:

Using wind turbines in conjunction with generators, wind energy is another renewable energy source that may be utilized to produce electrical power. Wind energy has many benefits, including the ability to generate electricity through wind turbines, generate mechanical power through windmills, pump water using wind pumps, and more. In order to create power, large wind turbines are designed to rotate with the wind. Cut-in speed is the minimum wind speed needed to connect the generator to the power grid, and cut-off speed is the maximum wind speed needed to disconnect the generator from the power grid. Wind turbines typically operate in the speed range between cut-in and cut-off speeds.

4. Wind Turbine:

A wind turbine is a fan with three blades that rotates when wind blows through it; the axis of rotation must line up with the wind's direction. A gear box is referred to as a high-precision mechanical system because it uses a mechanical process to transfer energy from one device to another. Although there are other varieties of wind turbines, horizontal axis and vertical axis wind turbines are the most commonly employed. The image depicts the various wind turbine generator system blocks.

5. Wind Turbine Generator:

It is called a wind turbine generator because it combines an electrical generator with a wind turbine. There are various kinds of wind turbine generators, and depending on certain requirements, these generators can be directly connected to the electrical grid, loads, or batteries. There are generally four types:

1. A squirrel cage induction generator can be directly linked to the electrical grid or can be used with the proper converters to supply AC or DC loads.
2. The power grid is connected to a generator and an AC to DC to AC converter.
3. A wind rotor induction generator that is powered by the grid or batteries and has rheostats to control speed to maintain desired outputs.
4. A grid-connected induction generator with two feeds whose speed can be adjusted with back-to-back converters.

6. System block diagram:

The solar wind hybrid system block diagram, which uses wind turbines and solar panels to generate electricity, is displayed in the figure. Using wind turbines in conjunction with generators, wind energy is another renewable energy source that may be utilized to produce electrical power.

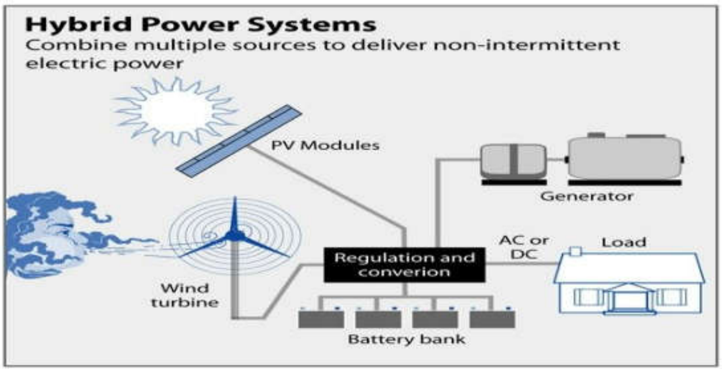


Fig.1. Hybrid power system

A fan with two or three blades that rotates when wind blows through it is called a wind turbine. The axis of rotation of the fan must line up with the direction of the wind. A gear box is referred to as a high-precision mechanical system because it uses a mechanical process to transfer energy from one device to another. Although there are other varieties of wind turbines, horizontal axis and vertical axis wind turbines are the most commonly employed. The system's block diagram shows a battery, buck converter, and solar panel. The sun energy is transformed into electrical energy by the solar panel.

The solar panel in use typically has a voltage rating of 12V. Solar energy is converted to electrical energy using the PHOTOELECTRIC EFFECT concept. The electrons in the valence band absorb energy and become excited when light strikes a material's surface. They become free when they leap to the conduction band. Some come to a junction where a Galvani potential accelerates them into a different substance. Electric energy is produced as a result of this electromotive force. Buck converters are dc-dc converters made up of a diode, inductor, capacitor, and MOSFET switch (IRF250N).

7. Hardware description:

7.1. Solar panel:

A collection of electrically connected solar photovoltaic modules installed on a supporting structure is called a solar panel. A solar cell assembly that has been packaged and connected is called a photovoltaic module. The solar panel can produce and supply electricity for both home and commercial purposes as part of a larger photovoltaic system. An inverter, a panel or array of solar modules, and occasionally a battery, solar tracker, and connection cable are the standard components of a photovoltaic system. One method of using solar energy to generate electricity is through photovoltaic cells or panels. Although they are the most convenient to utilize on a small to medium scale, they are not the most effective.

Silicon used to make computer "chips" is also utilized to make PV cells. Even though silicon is a widely common mineral, solar cell production, like that of computer chips, requires an extremely clean atmosphere. High production costs result from this. The two silicon types that make up a photovoltaic cell generate a voltage differential across them when exposed to solar radiation, which causes a current to flow if the cell is linked to an electrical circuit. A "module" is made up of several photovoltaic cells that are coupled together and typically housed in a glass frame that may be installed as needed. To generate a certain voltage, the cells in a module will be wired either in parallel or series.

Fig.2. Solar panel

7.2. DC motor:

Despite producing 60 RPM at 12V, the 60RPM Center Shaft Economy Series DC Motor is a high-quality, reasonably priced DC geared motor that operates smoothly between 4V and 12V and provides a wide range of RPM and torque.

Fig.3. motor

7.3. Boost Converter:

A boost converter, also known as a step-up converter, is a DC-to-DC power converter that increases voltage from its input (supply) to its output (load) while decreasing current. This type of switched-mode power supply (SMPS) has at least one energy storage component, such as an inductor, capacitor, or both, and two semiconductors, such as a transistor and a diode. Capacitor-based filters (often in conjunction with inductors) are typically added to the input (supply-side filter) and output (load-side filter) of such a converter in order to reduce voltage ripple. To increase voltage, battery power systems frequently stack cells in series. However, due to size constraints, many high voltage applications cannot stack cells sufficiently. Boost converters can lower the number of cells while raising the voltage. Boost converters are utilized in two battery-powered applications: lighting systems and hybrid electric vehicles (HEV).

Fig.4. Boost Converter

7.4. Solar Charge Controller:

In essence, a charge controller or regulator regulates voltage and/or current to prevent batteries from becoming overcharged. It controls the current and voltage that the solar panels send to the battery. The majority of "12 volt" panels emit between 16 and 20 volts, so overcharging will harm the batteries if there is no regulation. The majority of batteries require between 14 and 14.5 volts to completely charge. Usually, but not always. In general, trickle charge panels, such the 1 to 5-watt ones, or small maintenance panels don't require a charge controller. Generally speaking, you don't need a panel if it produces 2 watts or less for every 50 battery amp-hours.

Charge controllers are available in a wide variety of sizes, styles, functions, and pricing points. They range from the compact SunGard 4.5 amp control to the computer-interfaced 60 to 80 amp MPPT programmable controllers. Two or more 40 to 80 amp units are frequently wired in parallel if currents greater than 60 amps are needed. Although some of the modern MPPT controls, like the Outback Power FlexMax, can handle up to 80 amps, the most widely utilized controls for all battery-based systems fall between 4 and 60 amps.

7.4.1. There are three broad categories of charge controllers, some of which overlap:

Simple one- or two-stage controls that regulate the voltage in one or two steps using relays or shunt transistors. When a specific voltage is reached, these basically merely cut off or detach the solar panel. Although these are practically extinct, you can still find some of them on outdated systems, including some of the incredibly low-cost ones that are available online. Their dependability is their sole true selling point; with so few parts, there isn't much to break. Morningstar, Xantrex, Blue Sky, Steca, and numerous others are examples of 3-stage and/or PWM systems. Some of the older shunt/relay types are still in use today, such as in the extremely low-cost systems provided by mass marketers and discount stores, but these are essentially the industry standard.

Maximum power point tracking (MPPT) systems, including those manufactured by Morningstar, Xantrex, Outback Power, and Midnite Solar. With efficiency in the 94% to 98% range, these controllers are the best available and come at a comparable price. However, because they give the battery 10 to 30% more power, they can save a significant amount of money on bigger systems. See our article on MPPT for additional details. The majority of controllers have some sort of indicator, such as digital meters, a series of LEDs, or a basic LED. Computer interfaces for monitoring and control are now included into many of the more recent models, such the Outback Power, Midnite Classic, Morningstar MPPT, and others.

Typically, the most basic models merely include a few tiny LED lights that indicate power and charge. The majority of people using meters will display both the battery voltage and the voltage and current flowing from the panels. Additionally, some display the amount of current being drawn from the LOAD terminals.

Fig.5. Solar Charge controller

7.5. Inverter:

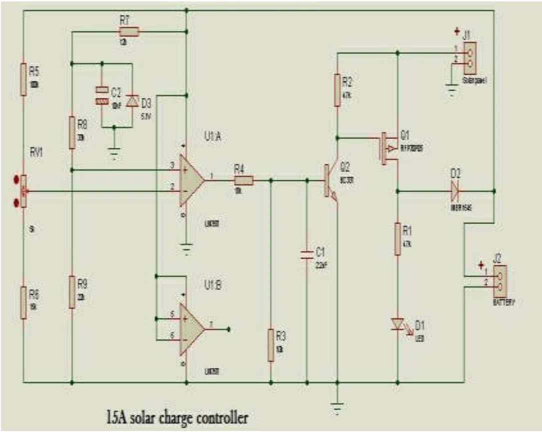
A motor control that modifies an AC induction motor's speed is called an inverter. It accomplishes this by altering the frequency at which the motor receives AC electricity. Additionally, an inverter modifies the motor's voltage. Six different power devices are controlled by complex electronic circuitry used in this operation. They create a three-phase AC voltage simulation by turning on and off. Inverting DC bus voltage and current into the AC waveforms applied to the motor is another name for this switching procedure. Thus, the term "inverter." The word "inverter" will be used instead of "adjustable speed drive" for the remainder of this discussion.

The majority of inverters are designed with variable voltage and frequency. A converter portion, a bus capacitor section, and an inverting section make up their composition. The incoming fixed voltage, fixed frequency, three-phase AC power is rectified (converted) to DC voltage by the converter section using semiconductor devices, and the DC voltage is then stored in the bus capacitor bank. There, it turns into a consistent current source for the power components, which are situated in the so-called inverting portion. Power from the DC bus cap bank is absorbed by the inverting section, which then reverses it back into simulated three-phase AC sinewaves with variable voltage and frequency, which are commonly used to adjust a three-phase induction motor's speed.

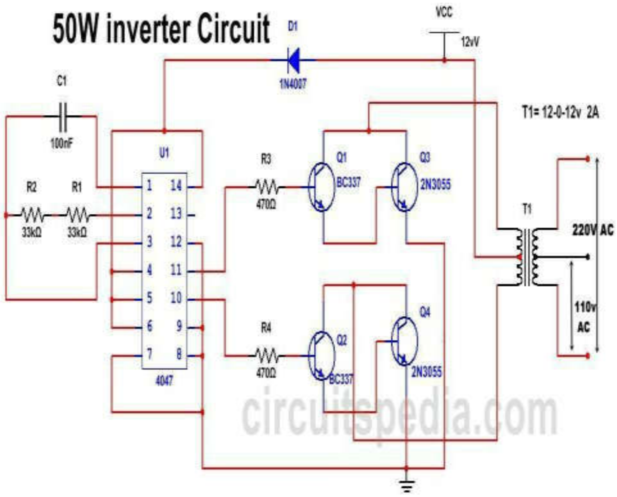
Fig.6. SD 12 VOLT DC converter

8. SYSTEM IMPLEMENTATION

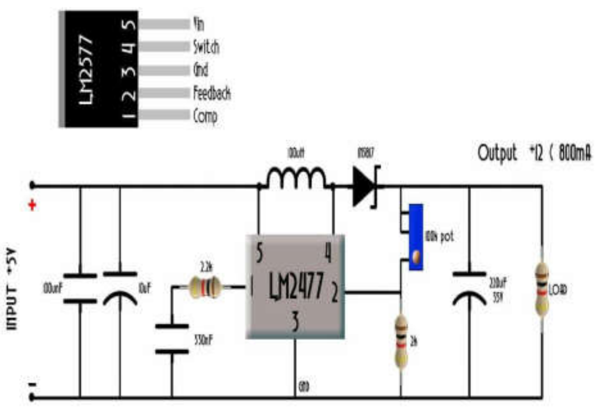
8.1. Fig.7. Solar charge controller:



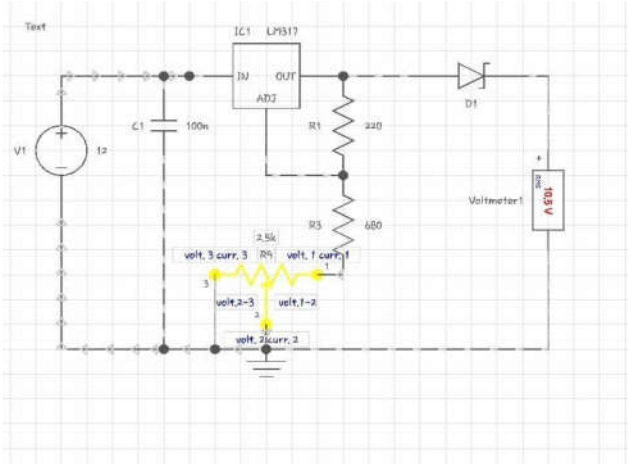
8.2. Fig.8. Inverter:



8.3. Fig.9.Boost converter:



8.4.Fig.10. LM317 Voltage Regulator:



8.5. Fig.11. Project OUTPUT:

9. Findings and Observations:

Let i be the internal drop current in the charger controller module, voltage be V, and solar and wind currents be i1 and i2, respectively. Total power now is - V (i1+i2-i).

Let ΰ = 0.85 be the inverter's efficiency.

Thus, hybrid power in the system's AC form, ΰ = 0.85 V (i1+i2-i) The procedure is not yet finished, but it will be shortly.

10. Project Applications:

1. Installing power systems units in every apartment in remote places.
2. Structures with multiple stories
3. Houses and educational institutions.
4. A wide region is illuminated by street lighting.
5. Applications outside the grid.
6. Solar-powered water heaters. Solar-powered automobiles and electric kettles
7. In several applications, including traffic signaling.

11. The benefits of hybrid solar energy systems include:

1**. Constant power supply**: Because the hybrid solar systems' batteries store energy, they can offer power continually and without interruption. Therefore, the batteries serve as an inverter to give you backup power in the event of an electrical outage. This is also true at night or in the evening when there is no sunlight and no energy is produced; life continues uninterrupted by the backup that batteries supply.

2. Make the best use of renewable energy sources: The excess energy produced on sunny days is not wasted since the batteries are connected to the system to store the energy. Thus, these systems optimize the usage of renewable energy by storing energy on a good day and using it on a bad day. The equilibrium is preserved.

3. Low maintenance cost: Compared to conventional generators that run on diesel, hybrid solar energy systems require less maintenance. They don't need regular maintenance and don't use any gasoline.

4. High efficiency: Under some circumstances, hybrid solar energy systems are more efficient than conventional generators, which lose fuel. Without wasting fuel, hybrid solar systems operate effectively in any kind of environment.

5. Load management: Most hybrid solar power systems control load appropriately, in contrast to conventional generators that deliver high power as soon as they are turned on. Technology in a hybrid solar system may be able to modify the energy supply based on the devices it is connected to, such as a fan that uses less power or an air conditioner that needs more.

12. Conclusion:

The hybrid power generating system that combines wind and solar energy offers a dependable, economical, and environmentally responsible way to meet energy demands. Regardless of the time or weather, it guarantees a consistent power supply by combining two complementing renewable sources. It is anticipated that hybrid renewable systems will be crucial to accomplishing sustainable development goals as technology continues to evolve and costs come down. Since the connection is not supported by the major players and is not economically viable, it is now not possible to reach the rural population that is not electrified by extending the grid. Furthermore, traditional energy solutions like fuel genset-based systems are gradually being removed from the agendas for rural development due to the rising costs of oil and the intolerable effects this energy source has on both consumers and the environment. Therefore, in order to offer sustained access to power and to promote development, infrastructure investments in rural regions must be tackled using cost-competitive, dependable, and efficient techniques. Nowadays, one of the best, if not the only, options for supplying electricity in dispersed areas or at specific distances from the grid are renewable energy sources. Indeed, by improving energy supply security, lowering greenhouse gas emissions and other pollutants, and generating local jobs that improve living conditions and general social welfare, renewable energy sources are already helping to achieve significant economic, environmental, and social goals. The best way to provide rural communities with "high quality" community energy services at the lowest possible cost while maximizing social and environmental advantages has been shown to be through hybrid systems. In fact, developing nations can increase consumption through economic expansion and stabilize CO2 emissions by opting for renewable energy.

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