A Hybrid Power Generation System by Solar Energy and Wind Energy

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Abstract - *Renewable energy sources i.e., energy generated from solar, wind, biomass, hydropower, geothermal and ocean resources are considered as a technological option for generating clean energy. But the energy generated from solar and wind is much less than the production by fossil fuels, however, electricity generation by utilizing PV cells and wind turbine increased rapidly in recent years. This paper presents the Solar-Wind hybrid Power system that harnesses the renewable energies in Sun and Wind to generate electricity. Power. Solar panels are used for converting solar energy and wind turbines are used for converting wind energy into electricity. This electrical power can utilize for various purpose. Generation of electricity will be takes place at affordable cost System. This hybrid solar-wind power generating system is suitable for Industries and also domestic areas.*

Solar panels are mounted on the surfaces of a wind turbine such that the combined energy from the wind turbine and the solar panels are provided as an output. Here electric DC energy produce from solar paper and wind turbine system.

Key Words: **Renewable energy generation system, Green energy, Free energy, Renewable resources, Natural hybrid energy system**

1. INTRODUCTION

1.1 A HYBRID POWER GENERATION:

Due to the critical condition of industrial fuels which include oil, gas and others, the development of renewable energy sources is continuously improving. This is the reason why renewable energy sources have become more important these days. Few other reasons include advantages like abundant availability in nature, eco-friendly and recyclable. Many renewable energy sources like solar, wind, hydel and tidal are there. Among these renewable sources solar and wind energy are the world's fastest growing energy resources. With no emission of pollutants, energy conversion is done through wind and PV cells.

Day by day, the demand for electricity is rapidly increasing. But the available base load plants are not able to supply electricity as per demand. So, these energy sources can be used to bridge the gap between supply and demand during peak loads. This kind of small-scale stand- alone power generating systems can also be used in remote areas where conventional power generation is impractical.

In this, a wind-photovoltaic hybrid power generation system model is studied. A hybrid system is more advantageous as individual power generation system is not completely reliable. When any one of the systems is shutdown the other can supply power. The present invention relates to a solar-paneled Windmill for producing electrical energy using Wind and solar energy. Many Windmills operate without any input from solar energy that is freely available. The current invention uses Wind and solar energy to produce electrical energy. Additionally, in another embodiment, Well-placed solar-paneled mount on Windmill fan blades yield additional electrical energy output.

1.2 HISTORY:

Hybrid renewable energy systems (HRES) are becoming popular as stand-alone power systems for providing electricity in remote areas due to advances in renewable energy technologies and subsequent rise in prices of petroleum products. A hybrid energy system, or hybrid power, usually consists of two or more renewable energy sources used together to provide increased system efficiency as well as greater balance in energy supply.

Another example of a hybrid energy system is a photovoltaic array coupled with a wind turbine this would create more output from the wind turbine during the winter, whereas during the summer, the solar panels would produce their peak output. Hybrid energy systems often yield greater economic and environmental returns than wind, solar, geothermal or regeneration stand- alone systems by themselves.

1.3 CLASSIFICATION OF VARIOUS TYPES OF RENEWABLE RESOURCES:

i. Solar energy
ii. Wind energy
iii. Hydro energy
iv. Tidal energy
v. Geo-thermal energy

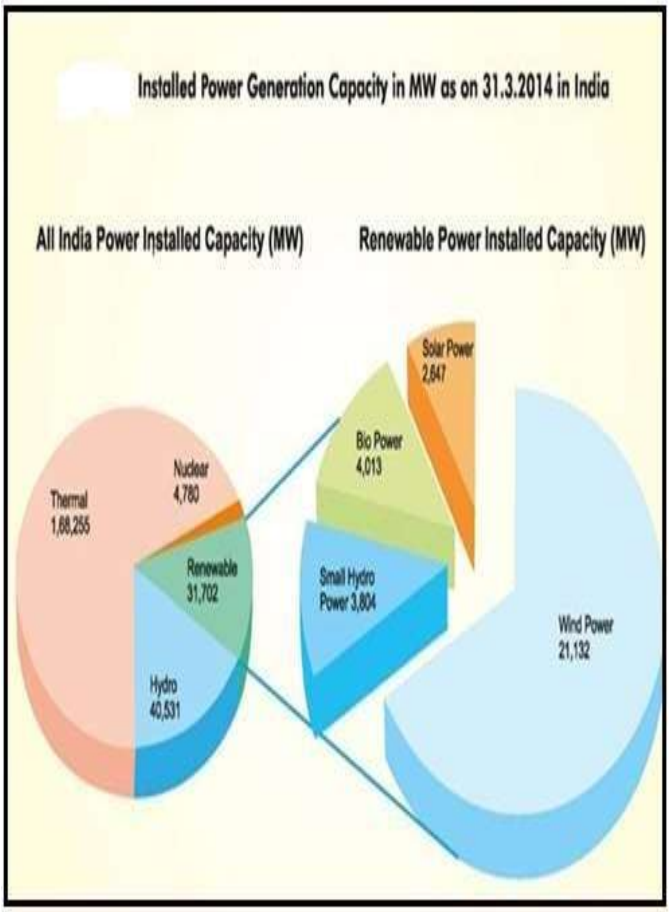

Figure 1.Flow Chart of Renewable Energy

CHAPTER 2. DIFFERENT SYSTEMS AND DIAGRAM

2.1 BASIC BLOCKDIAGRAM OF SYSTEM:

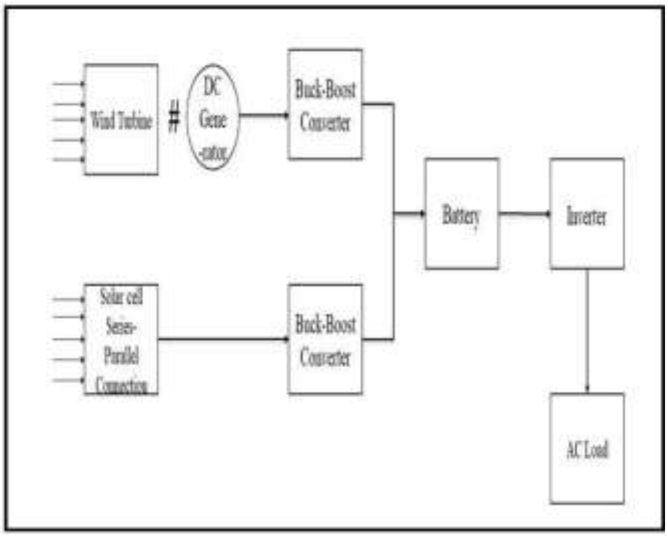

Figure 2.Block Diagram of Hardware Implementation

Solar plate implant to wind blade surface & wind turbine base. Connect solar cell to series & parallel to as a required. Using buck boost converter maintain 12V output of each power & stored the energy in battery bank. Inverter can convert DC to AC power.

2.2 WIND TURBINE:

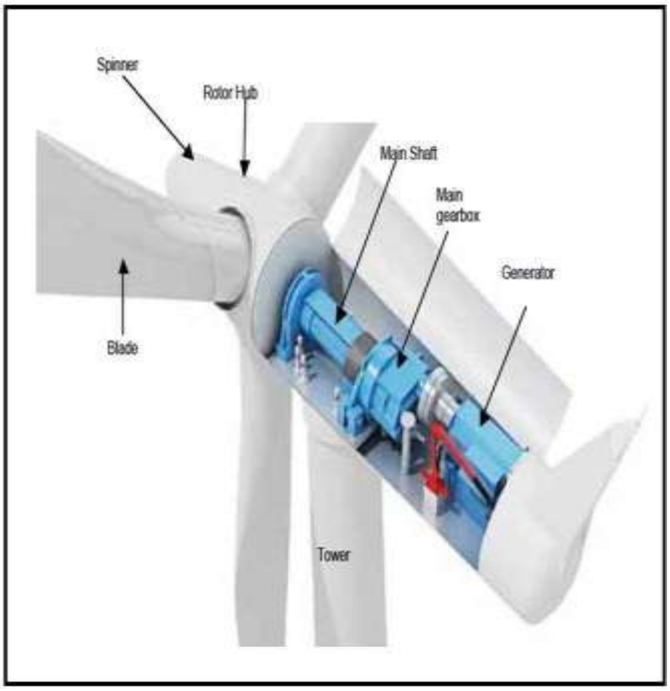

Figure 3.Wind Turbine

Wind turbine is that system which extract from wind by rotation of the blades of wind turbine. Basically, wind turbine has two types one is vertical and another is horizontal. As the wind speed increases power generation also increases. The power generated from wind is not continuous its fluctuating. For obtain the non-fluctuating power we have to store in battery and then provide it to the load.

The wind energy is a renewable source of energy. Wind turbines are used to convert the wind power into electric power. Electric generator inside the turbine converts the mechanical power into the electric power. Wind turbine systems are available ranging from 50W to 3-4 MW. The energy production by wind turbines depends on the wind velocity acting on the turbine. Wind power is able to feed both energy production and demand in the rural areas. It is used to run a windmill which in turn drives a wind generator or wind turbine to produce electricity.

We used normal small fan blades.

2.3 SOLAR CELL

2.3.1 Working principal of PV cell:

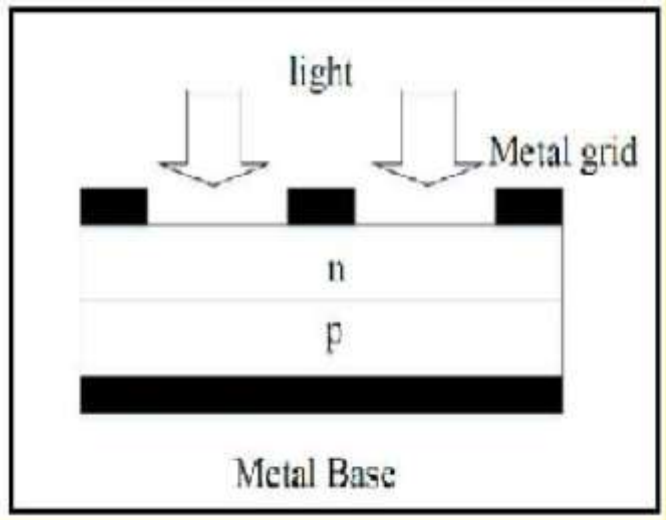

Figure 4. PV Cell

Photons in sunlight hit the solar panel and are absorbed by semiconducting materials, such as silicon germanium. Electrons (negatively charged) are knocked loose from their atoms, allowing them to flow through the material to produce electricity. Due to the special composition of solar cells, the electrons are only allowed to move in a single direction. An array of solar cells converts solar energy into a usable amount of direct current (DC) electricity.

Sunlight is composed of photons, or particles of solar energy that contain various amounts of energy corresponding to the different wavelengths of the solar spectrum. The electrons present in the valence band absorb energy and, being excited, jump to the conduction band and become free. These highly excited electrons are accelerated into a different material by a built-in potential. This generates an electromotive force, and thus some of the light energy is converted into electric energy. When sun light falls on silicon metal cell, the photon energy allows the electrons from the P-layer to move to the N-layer, creating an electric potential difference on the semiconductor borders. If these borders are connected to a load by conductive wires, there will be a flow of electric current, getting back the electrons to the P-layer and starting the process again.

A photovoltaic cell generally has low current and voltage levels, of about 3 A and 0.7 V, respectively.

i. First layer is metal conductor strips in PV cells.

ii. Second layer is antireflecting coting.

iii. N-type silicon layer.

iv. P-type silicon layer.

v. Metal back plate.

2.3.2 Two types of connection of solar cell:

1. Series Connection
2. Parallel Connection

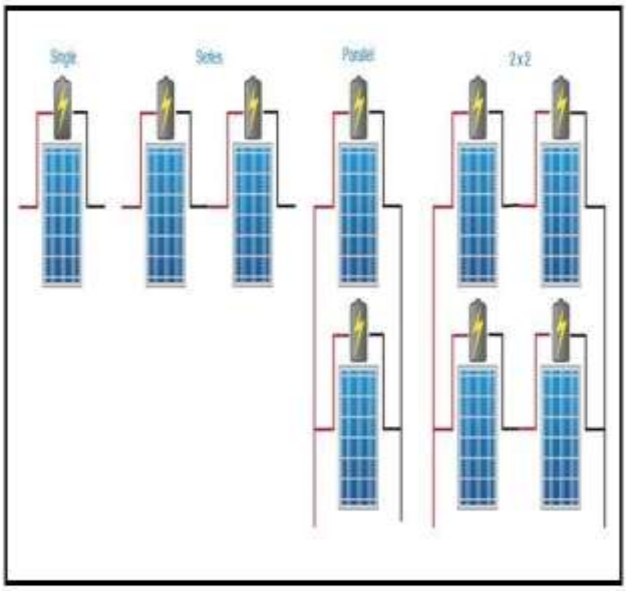

Figure 5.Connection of PV Cell

Solar panel is connecting in series and parallel. When solar panel is connected in series that time voltage increased and current will be same. When solar panel is connected in parallel that time current increased and voltage will be same.

2.3.3 EQUIVALENT CIRCUIT AND CHARACTERISTICS OF PV SYSTEM

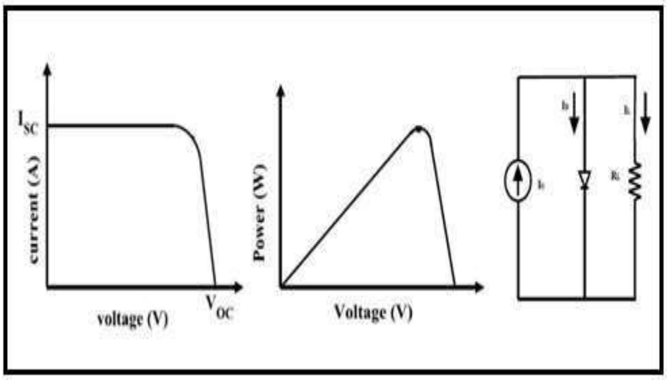

Figure 6.Equivalent circuit of single diode modal of solar cell

$$I_d = I_s\,(e^{\lambda} * v - 1) \quad \ldots\ldots\ldots\ldots\ldots (1)$$

$$\lambda = \frac{e}{K*T} \quad \ldots\ldots\ldots\ldots\ldots (2)$$

Where,

K=Boltzmann constant

E=electronic charge

T=cell temperature in degree

Load current $IL = Ig - Id = Ig - I_s(e^{\lambda} * v - 1)$ ....(3)

From this equation,

$$Voc(IL = 0) = \left(\frac{1}{\lambda}\right) * \ln\left(\left(\frac{Ig}{Is}\right) + 1\right) \quad \ldots\ldots\ldots\ldots (4)$$

$$Isc\ (V = 0) = Ig \quad \ldots\ldots\ldots (5)$$

2.4 DC GENERATOR:

The shaft of the wind turbine is mechanically coupled to the rotor shaft of the generator, so that the mechanical power developed by the wind turbine (by kinetic energy to mechanical energy conversion) is transmitted to the rotor shaft. This rotor structure has a rotor winding (either field or armature). In both the cases, we get a moving conductor in a stationary magnetic field or a stationary conductor in moving magnetic field. In either case, electric voltage is generated by the generator principle.

Generators can be basically classified on the type of current. There are alternating current generators and direct current generators. But in either case, the voltage generated is alternating. By adding a commutator, we convert it to direct current.

2.5 DC to DC CONVERTER:

DC-DC converter is an electrical circuit whose main application is to transform a dc voltage from one level to another level. It is similar to a transformer in AC source, it can able to step the voltage level up or down. The variable dc voltage level can be regulated by controlling the duty ratio (on-off time of a switch) of the converter.

There are various types of dc-dc converters that can be used to transform the level of the voltage as per the supply availability and load requirement. Some of them are discussed below.

1. Buck converter
2. Boost converter
3. Buck-Boost converter

Each of them is explained below.

2.5.1 BUCK CONVERTER:

The functionality of a buck converter is to reduce the voltage level.

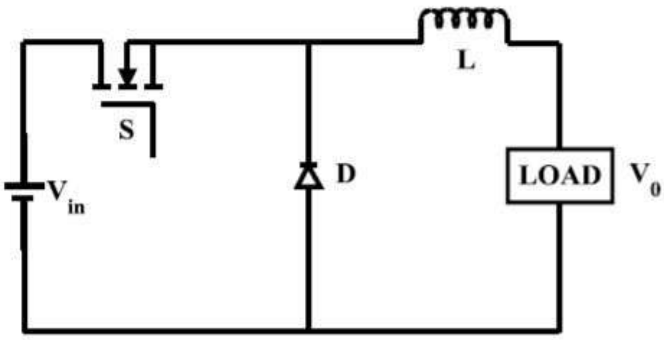

Figure 7.Buck Converter

When the switching element is in state of conduction the voltage appearing across the load is Vin and the current is supplied from source to load. When the switch is off the load voltage is zero and the direction of current remains the same. As the power flows from source side to load side, the load side voltage remains less than the source side voltage. The output voltage is determined as a function of source voltage using the duty ratio of the gate pulse given to the switch. It is the product of the duty ratio and the input voltage.

2.5.2BOOST CONVERTER:

The functionality of boost converter is to increase the voltage level.

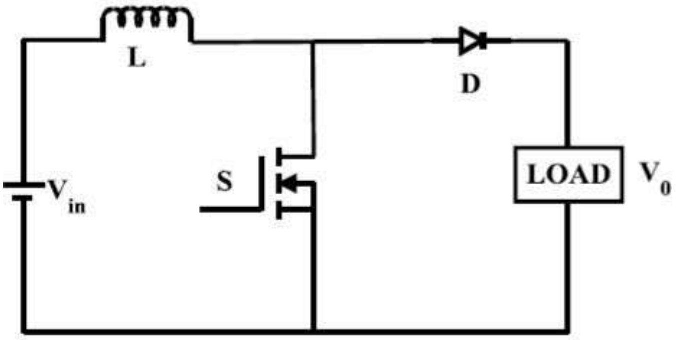

Figure 8.Boost Converter

The current carried by the inductor starts rising and it stores energy during ON time of the switching element. The circuit is said to be in charging state. During OFF condition, the reserve energy of the inductor starts dissipating into the load along with the supply. The output voltage level exceeds that of the input voltage. And is dependent on the inductor time constant. The load side voltage is the ratio of source side voltage and the duty ratio of the switching device.

2.5.3 BUCK-BOOST CONVERTER:

The functionality of a buck-boost converter is to set the level of load side voltage to either greater than or less than that of the source side voltage. The circuit configuration of the buck-boost converter is manifested in figure.

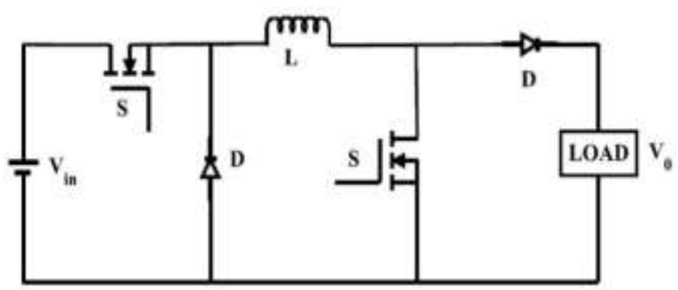

Figure 9.Buck Boost Converter

When the switches are in the state of conduction, the current carried by the inductor starts rising and it stores energy. The circuit is said to be in charging state. While the switches are in the OFF state, this stored energy of the inductor is dissipated to the load through the diodes. The output voltage can be varied based on the On-time of the switches. The buck-boost converteracts as both buck and boost converters depending on the duty cycle of the switches. For the duty ratio less than 50% it acts as a buck converter and for the duty ratio exceeds than 50% it acts as boost converter. As the voltage can be stepped both up and down, we use buck-boost converter for our convenience in our work.

2.6 BATTERY:

We have to choose battery bank size per the load requirement so that it should fulfill the requirement of load for calculating the battery size we need to find following data:

1. Find total daily use in watt-hour (wh)
2. Find total back up time of the battery

The batteries in the system provide to store the electricity that is generated from the wind or the solar power. Any required capacity can be obtained by serial or parallel connections of the batteries. The battery that provides the most advantageous operation in the solar and wind power systems are maintenance free dry type and utilizes the special electrolytes. These batteries provide a perfect performance for long discharges.

We used 24 V Battery.

2.7 INVERTER:

We have to choose greater rating inverter then the desired rating. The pure sine wave inverter is recommended in other to prolong the lifespan of the inverter.

Inverter is need to convert DC power into AC power.

As our load working on the AC supply so we need to convert DC power. The input voltage, output voltage and frequency and overall power handling depends on the design of the specific device or the circuitry.

Energy stored in the battery is drawn by electricals loads through the inverter, which converts DC power into AC power. The inverter has in-built protection for Short-Circuit, Reverse Polarity, Low Battery Voltage and Over Load.

CHAPTER 3: DESIGN AND RESULTS

3.1 CALCULATION OF WIND TURBINE:

Here, we use the Dynamo.
Generated emf=4.44 $* f * \phi * t$

The calculation of wind energy,

$$P_W = \left(\frac{1}{2}\right) * \rho * A_W * V^3 \qquad \text{……….. (1)}$$

Where;

P=power in watts

ρ=the air density in kg/m^3

Aw=the swept area by air in m^2

V=wind speed in m/s

The total power generated by this system may be given as the addition of the power generated by the solar PV panel and power generated by the wind turbine.

Mathematically it can be represented as,

$$Pt = (Nw * Pw) + (Ns * Ps) \qquad \text{………. (2)}$$

Where,

Pt= Total Power Generated

Pw= The Power Generated by Wind Turbine

Ps= The Power Generated by Solar Panel

Nw= Number of Wind Turbine

Ns= Number of Solar Panel

3.2 CALCULATION OF SOLAR ENERGY:

MATHEMATICAL SOLUTION:

Solar Panel Calculation:

Solar Cell Data:

1 Cell= Voltage=0.6

Using 20 Cells in Series.

Vt= 20*0.6=12 volt

Energy Conversion
Efficiency:

$$\eta = \left(\frac{Pm}{E * A}\right) * 100$$

Where,

η=Energy Conversion Factor

Pm=Maximum Power Output (watt)

E=Solar Energy, Insolation, W/m^2

A=Area of the Solar Cell

EXAMPLE:

Pm=175 watt

A=0.75*1.50=1.125 m^2

E=1000 W/m^2

$$\eta = \left(\frac{Pm}{E * A}\right) * 100$$

= (175/ (1000*1.125)) *100

η=15.6%

3.3 SIMULATION WORK

3.3.1 SIMULATION OF SOLAR CELL:

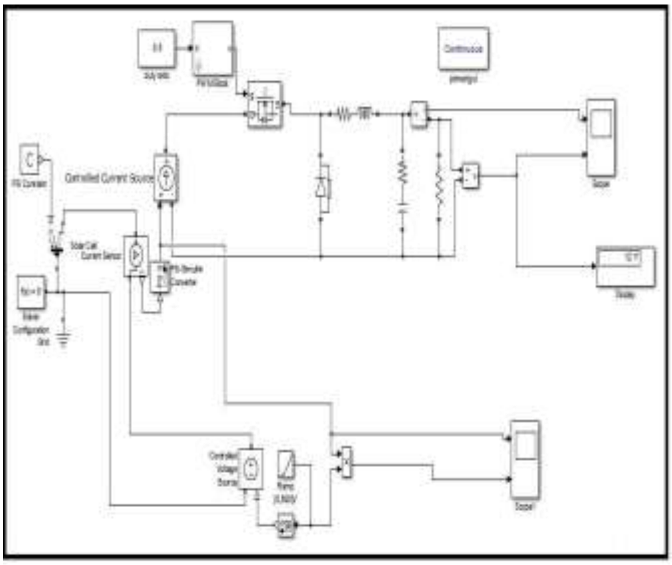

Figure 10.SIMULATION OF SOLAR CELL

WAVE FORMS:

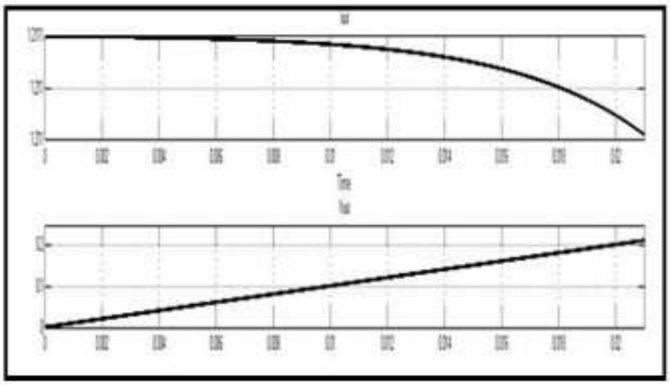

Figure 11.Waveform of Solar Cell

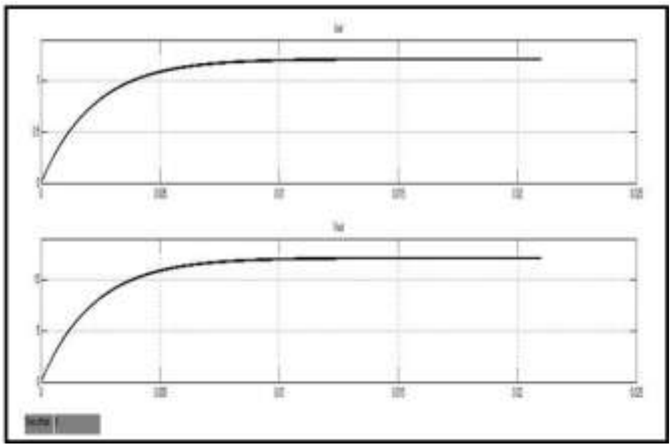

Figure 12.Waveform of Solar Cell

Table 1. Solar Module Voltages with Different Irradiance

NO.	IRRADIANCE	VOLTAGES
1	100	7.33 V
2	200	14.68 V
3	300	22.02 V
4	400	29.36 V
5	500	36.70 V
6	600	44.04 V
7	700	51.38 V
8	800	58.72 V
9	900	66.05 V
10	1000	73.39 V

3.3.2 SIMULATION OF INVERTER

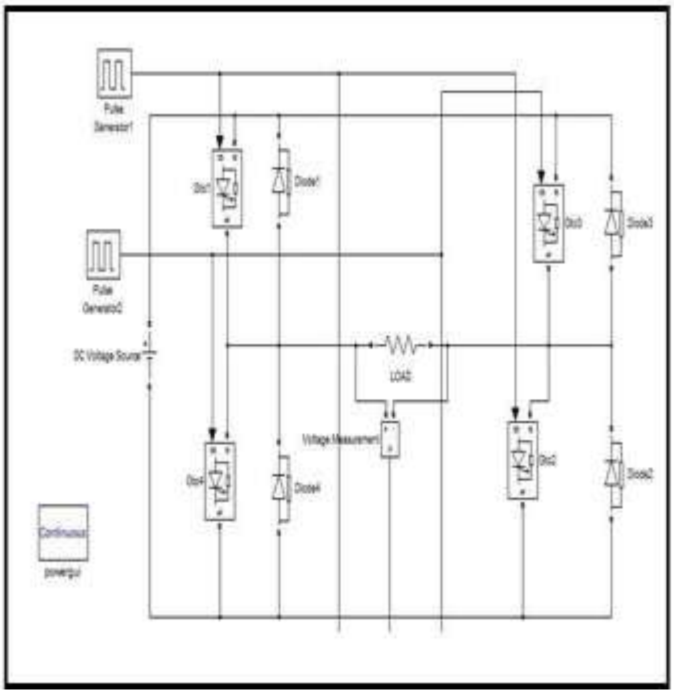

Figure 13.Simulation of single-phase full bridge Inverter

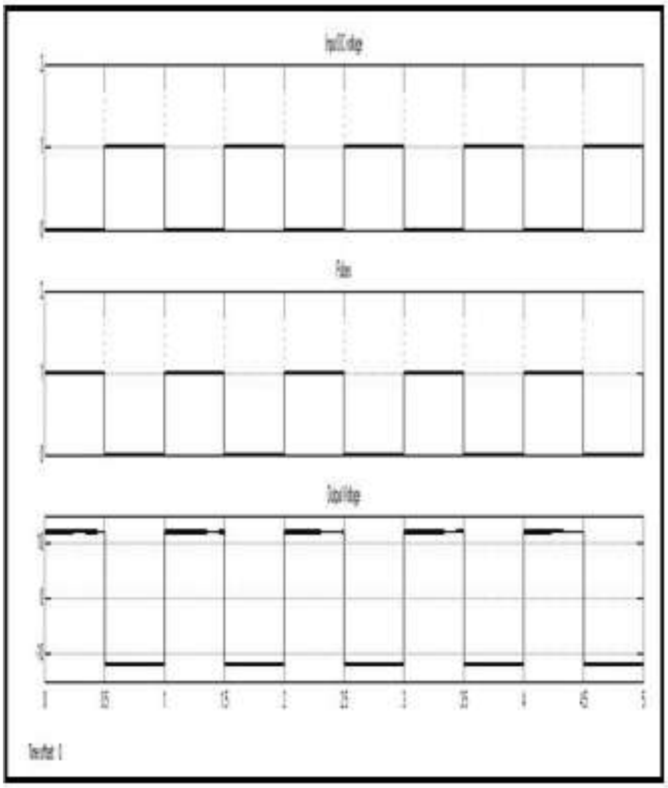

Figure 14.Waveform of single-phase full bridge Inverter

CHEPTER: 4 HARDWARE MODEL

4.1 HARDWARE MODEL:

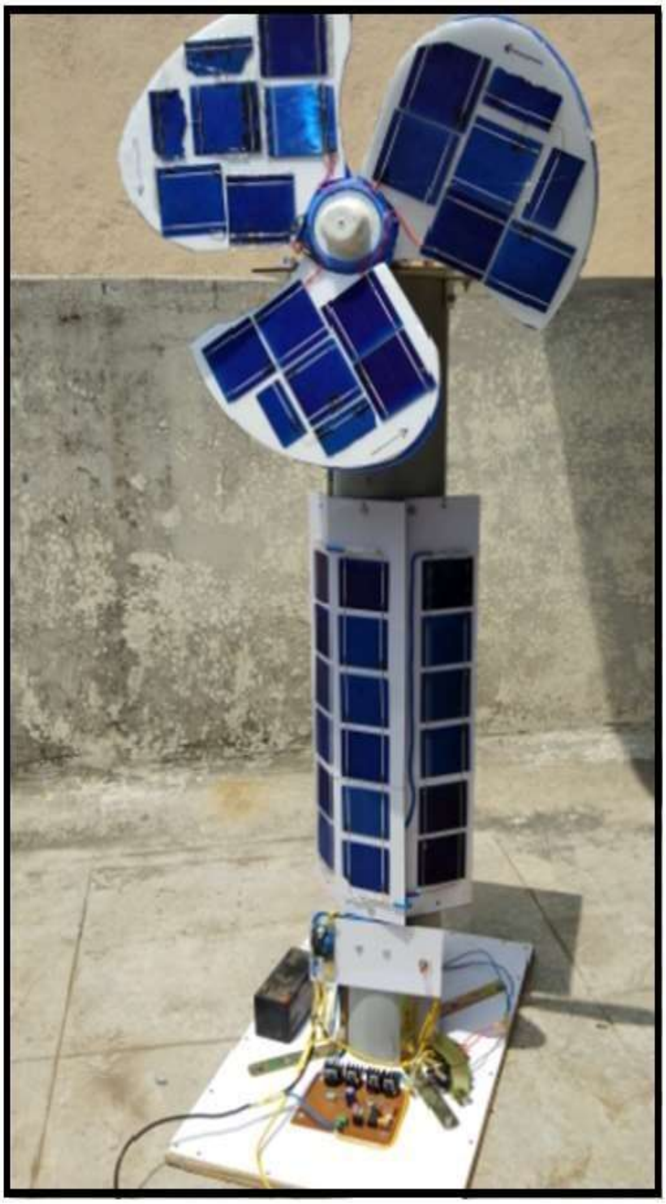

Figure 15.Hardware Model

4.2 WIND TURBINE

COMPONENT LIST:

Blade: Width- 22 cm and Height- 19 cm

Dynamo 12V, 60 RPM (Permanent Magnet)

Gears

Base 2 ft.

- **RESULT:**

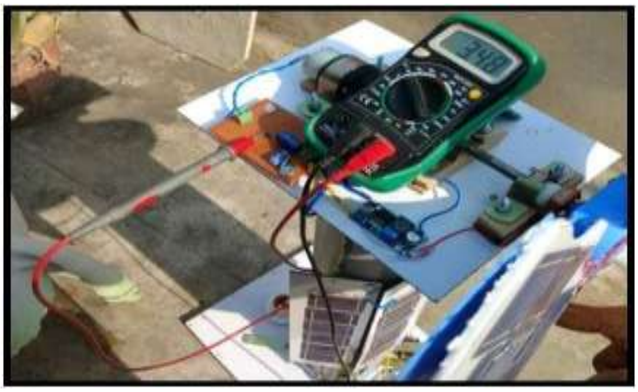

Figure 16.Result of Wind Turbine

4.3 SOLAR CELL:

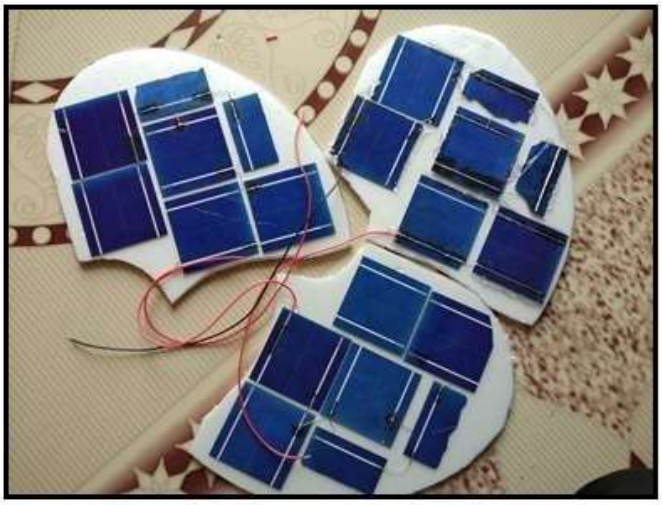

Figure 17.Implement of Solar Cell on Blade

COMPONENT LIST:

1 Blade= 3V and 1.2 amp

- RESULT:

Figure 18.Result of Solar Cell

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4.4 BUCK BOOST CONVERTER:

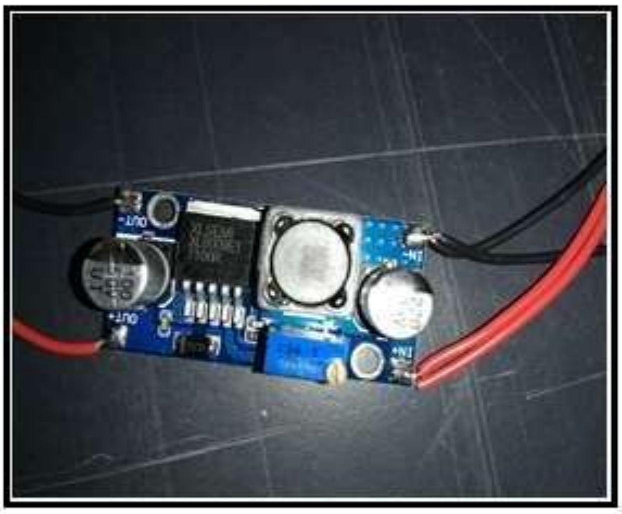

Figure 19.Construction of Buck Boost

- **COMPONENT LIST:**

1. Coil 330 μH
2. XL6009E ic
3. Capacitor (220μF/35V and 100μF/50V)
4. Resistor (Variable10KΩ and 220Ω fixed)
5. Diode

- **XL6009E ic DESCRIPTION**

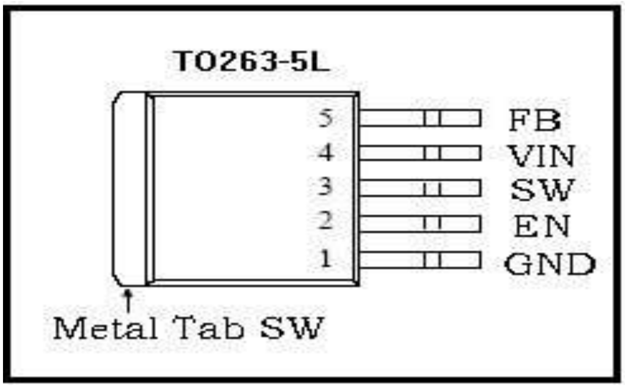

Figure 20.XL6009E ic

The XL6009 regulator is a wide input range, current mode, DC/DC converter which is capable of generating either positive or negative output voltages. It can be configured as either a boost, fly back, SEPIC or inverting converter. The XL6009 built in N-channel power MOSFET and fixed frequency oscillator, current-mode architecture results in stable operation over a wide range of supply and output voltages.

The XL6009 regulator is special design for portable electronic equipment applications.

- APPLICATION:

i. EPC / Notebook Car Adapter
ii. Automotive and Industrial Boost/Buck-Boost / Inverting Converters
iii. Portable Electronic Equipment

4.5 INVERTER:

- COMPONENT LIST:

i. MOSFET Z44N 60V
ii. Transistor SL100
iii. 7805 ic
iv. CD4007 Multi vibrator ic
v. Pre-set
vi. Capacitor (1000μF/25V), Ceramic Capacitor: (Small- 0.1 μF and Large- 47 nF)
vii. Resistor (10KΩ ,1KΩ and 220Ω)

- **7805 ic DESCRIPTION**

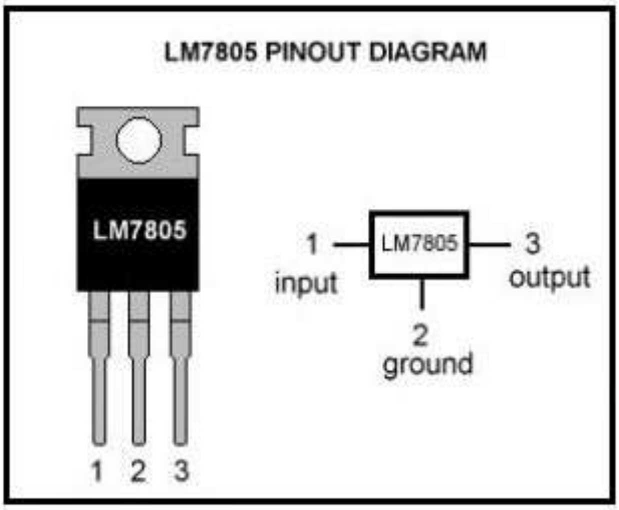

Figure 21.LM 7805 ic

This is Voltage Regulator ic.

IC regulator is mainly use in the circuit to maintain the exact voltage which is follow by the power supply. A regulator is mainly employed with the capacitor connected in parallel to the input terminal and the output terminal of ic regulator. For the checking of gigantic alteration in the input as well as in the output filter, capacitor is used. While the capacitor is used to check the small periods spikes on the input and output level. Bypass capacitors are mainly of small value that are used to bypass the small period pulses straightly into the earth.

- **CD4007 ic:**

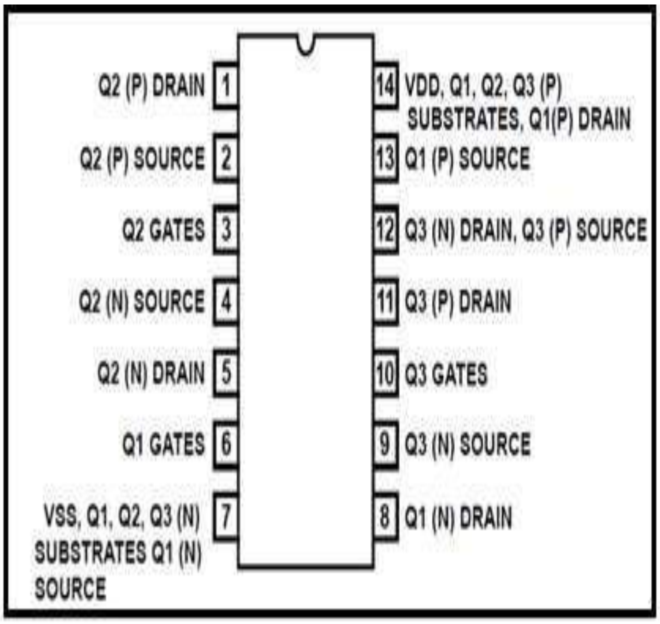

Figure 22.CD4007 ic

CD4007BMS types are comprised of three n-channel and three p-channel enhancement type MOS transistors. The transistor elements are accessible through the package terminals to provide a convenient means for constructing the various typical circuits. More complex functions are possible using multiple packages.

4.6 BATTERY:

- COMPONENT LIST:

1. 12V and 1.2 amp

4.7 TRANSFORMER:

- COMPONENT LIST:

1. 12-0-12 Center tap transformer

5. ADVANTAGES, DISADVANTAGES AND APPLICATION:

5.1 ADVANTAGES

i. High energy output.
ii. Cost saving.
iii. Clean and pure energy.
iv. No pollution.
v. Long term warranty.

5.2 DISADVANTAGES:

i. Higher installation cost.

5.3 APPLICATIONS:

i. The system can be designed for both off grid and on grid application.
ii. Industrial
iii. Domestic
iv. Small for House

CONCLUSION:

PV cell, module and array were mathematical modelled and simulated and the effect of environmental conditions were studied on their PV & IV characteristics. We studied about the different inverter topologies and their working. We have prepared Hardware model of Hybrid power generation and also observed that theoretical results are similar with results of hardware model.

FUTURE SCOPE:

Maximum power point can be tracked using different algorithms. Battery charge controller can be designed for more reliable operation and better battery life.

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