Small Scale Horizontal Wind Turbine System Using DC-DC Boost Converter

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Abstract : This paper describes small scale horizontal wind turbine system using DC-DC boost converter. In wind energy conversion system a dc wind generator converts mechanical energy into electrical energy. Voltage and frequency of generator output changes along with the wind speed. A DC-DC boost converter is used to maintain a constant dc voltage at battery side.[4] Inverter connected to battery which converts DC power to AC power that power is fed to load. This paper presents overview of Wind Energy Conversion System (WECS) and its experimental results.

Key Words: Boost converter, Wind generator, inverter, Battery, WECS .

1 INTRODUCTION

In the world the widely electricity produced by fossil fuel but it has various effect on environment so the necessary the alternative resource in power generation. The alternative source is Renewable energy source. There are different kinds of renewable energy source are available such as wind ,solar ,biomass etc. These are renewable source produces the electricity very clean , socially beneficial and economically for many application.

Among the all renewable sources the wind power generation is very suitable and easy for some application. In wind turbine system there are two types such as large scale wind turbine and small scale wind turbine. These large scale wind turbine used in large application and generate the electrically in MW. Where as the small wind turbine which generate the electricity in small power in Watt or KW. This small scale wind turbine used where the area is far form national grid system remotes area and home or small industrial application[1]. In this paper we design the small scale wind turbine.

The small scale wind turbine consist of Blade(Turbine), Turbine shaft, Generator , Tailrace and Yaw-mechanism. This wind turbine or blade rotate depend upon speed of velocity, air density and length of blade. This blade rotates and convert the kinetic energy of wind velocity to mechanical energy. The blade rotate because of wind flowing across the surface of wind blade. This mechanical energy rotate the shaft of turbine. This turbine shaft couple to the shaft of generation so the shaft of generator is rotate. So produces the electricity from the generator.

The permanent magnet DC motor used as generator which is produces the 24Volt DC supply. This DC supply stored in battery through battery charger circuit or Boost up circuit. The battery used in this project 12 Volt (7.5AH). From this battery the DC supply is used to inverter circuit.[1] This inverter circuit produces the 230 Volt AC supply. So from this project the 60 Watt AC load is operate. In this project various new technology or market available material used such as PVC material used for blade. The eight inch PVC pipe is used and it has less price and easily available in market. So this project made easy generation and very useful and inspiration generation to domestic purpose.

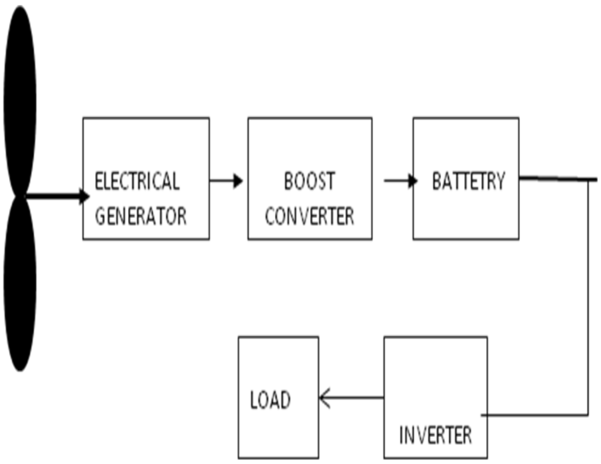
2 RECENT DEVELOPMENT

In recent year , wind energy has become one of the most economical renewable technology. Today, electricity generating wind turbines employ proven and tested technology and provide a secure and sustainable energy. At good wind sites, wind energy can already successfully complete with conventional energy production. The technological development of recent year, bringing more efficient and more reliable wind turbine, is making wind power cost effective. Many developing countries and emerging economics have substantial unexploited wind energy potential. In many locations, generating electricity form wind energy offers a cost-effective alternative to thermal power stations.

3.1 PROPOSED WORK

The block diagram gives detail about how the 12 Volt battery charge and how to switch on the AC load. The speed of wind velocity 4.0 m/s to 5.0 m/s require to rotate the blade or turbine. The blade converter the kinetic energy of wind to mechanical energy. This mechanical energy produced depend upon pitch curve of blade. Then this mechanical energy rotate the shaft. The one end of shaft is coupled to turbine and other end of shaft connected to generator shaft. Generator shaft is nothing but armature shaft. When the rotate the shaft the coupled generator shaft is rotate and produce the electricity power.

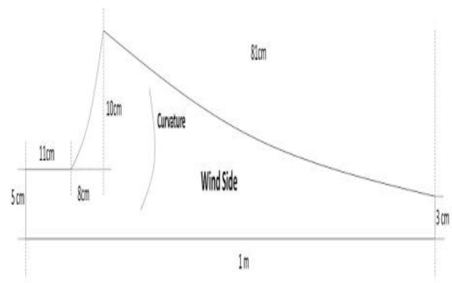
The output power is varied because of variation in wind velocity. So to supply constant power boost converter circuit used between generator and battery. Then constant continuously power stored in battery. But battery supply DC output power but generally AC load is used in daily life so after this battery inverter circuit is used. This circuit convert the 60 watt output power.



Block Diagram Of WECS

Fig 3.1 Proposed System

3.2 BLADE



In wind system the rotor/blade is very important part for generation of electrical energy. Mostly the material is used for rotor is Aluminum, steel, metal alloy in past year but in this project we design the rotor by new material such as PVC pipe because of it's various advantages most important advantage is it is light in weight, less cost, easily available and drag and leg cure is easily obtain[2].

In this eight inch PVC pipe is used and this pipe quarters into equally three part. The thickness of this pipe is 0.25mm and length of this rotor is 1m or 3.3foot. By using this dimension actual shape of blade is to obtain maximum drag force.

3.3 YAW SYSTEM

Fig.3.3 Actual Design of Yaw mechanism

The yaw system of wind mill is the component responsible for the orientation of the wind turbine rotor towards the wind.

3.4 GENERATOR

Fig.3.4 Generator

The generator is device which generate the electrical energy. In the past year for wind energy DC motor is used. Also synchronous motor is used for generation of electricity. Let large torque to rotate it armature shaft which is coupled to shaft of rotor. But wind turbine has less speed and torque so it is require gear for rotation of armature shaft of rotor. But in this project we generate the electricity by using permanent magnet geared coupled generator. This generator have inbuilt gear the rotation of the gear is 1:180. So starting torque to rotor the shaft is less and it is require small wind speed to turbine generate electricity. In fig 3.4 show the practical construction of generator. This geared coupled generator produce the 12 Volt DC and 0.8 Amp current. So it is very useful for various application such as battery charging and also useful in Dc lamp load.

3.5 TAIL

In this project, the material used is iron pipe and the thickness of the iron pipe is 0.25ft. The length of the tail stalk is put up 3ft because a tail length of between 3 ft and 4 ft works the best from tests and length of the blade is 3ft. Simply cut out a tail fin from the iron sheet and attach it to the back of the tail stalk assembly with hex bolts, nylon washers and SSTL washers. We can use any shape of tail fin to catch the wind enough. When wind speed is so much, blades can be damaged.[1] To protect from damage, the ring of spring is attached to the tail stalk.

3.6 BOOST CONVERTER

Boost converter (step up converter) is a DC to DC power converter with an output voltage greater than it's input voltage. Semiconductor (diode and transistor) and at least one energy storage element, a capacitor, inductor or normally the two in combination. Filters made of capacitor are normally connected to reduce voltage ripple.

Boost converter is designed to charge the 12 Volt 7.5 AH battery which is used to store the electrical energy. Because wind generator output is not sufficient to charge the battery. Here we use the boost converter which is capable of generating 15 Volt form 3.5 Volt input. Output of Boost converter which is constant 15 Volt is supplied to the battery. If wind generator output is more than 3.5 Volt it does not charge it's output voltage, it still supply constant output to battery.

3.7 INVERTER

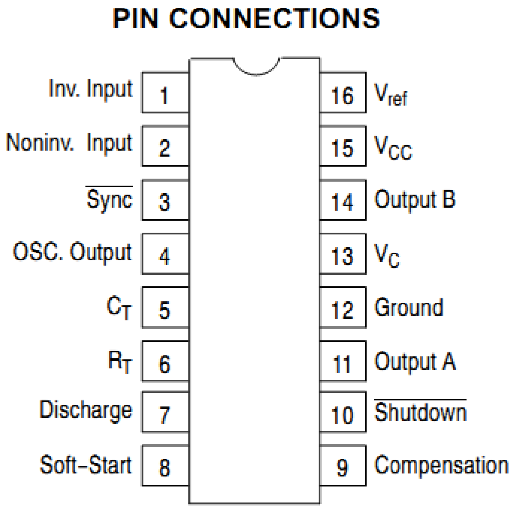


Fig 3.7 PIN Diagram of SG3525A

A inverter is an electronic device or circuitry that changes direct current to alternating current (AC). We use 12 V dc to 220 V dc inverter using IC SG3525A.PIN Diagram of ICSG3525A shown in Fig 3.7. IC SG3525A has an inbuilt oscillator whose frequency can be determined by connecting capacitor and resistor on pin 5 and pin 6 respectively. The frequency of oscillation is dependent on Timing resistance(RT), Timing capacitor(CT), Dead time resistance. The frequency of oscillation can be calculated by the equation ,

$$F=\frac{1}{CT(0.7RT+3RD)}$$

RT and RD in ohm and CT in F, F is HZ.

Output is taken from pin 11and 14 which are connected to gates of MOSFET. Pin 11 and 14 operate as push pull manner. It never turns ON two pins at the same time. The signal from pin 11and 14 are connected to the gates of power MOSFET NF 55which switch current to each winding of transform. Only one winding is activated at the time and both energized in opposite direction. Activation of winding in opposite direction helps to produce on alternating EMF and thus alternating current (AC) on the secondary of the transformer. The frequency of output AC is 50HZ which is determined by the CT and RT pins of SG3525A (pin 5 and 6).

Table -1: Generator Output

Wind speed versus voltage & currant			
Sr. No.	**Wind Speed (M/S)**	**Voltage(V)**	**Current(A)**
1	4	5	0.30
2	4.7	7	0.5
3	5	8	0.57
4	5.5	9	0.65
5	6	12	0.8

4 CALCULATION OF WECS

The kinetic energy of the air stream available for the wind turbine given by

$$E=\frac{1}{2}\rho v V^2 \text{ ....[1]}$$

Where, ρ is air density, v is the volume of air available to the wind turbine rotor and V is the velocity of wind stream in m/s.
The air parcel interacting with the rotor per second has a cross-sectional area equal to that of the rotor ($2\,A_T(m)$) and thickness equal to the wind velocity($V(m/s)$).
Hence power of air stream available for wind turbine given by,

$$P=\frac{1}{2}\rho A_T V^3 \text{ ......[2]}$$

However, wind turbine can not convert power of air stream completely. When the power stream passes the turbine, a part of its kinetic energy is transferred to the rotor and the air leaving the turbine carries the rest way. The actual power produced by wind turbine, usually, describe by power coefficient (C_P). C_P is the ratio of available power from wind stream and the power transferred to wind turbine[3]. Hence

$$C_P=\frac{2P_T}{\rho A_T V^3} \text{ .....[3]}$$

Where, P_T is the power available from wind stream. According to Betz's law, no turbine can capture more than 59.3 percent of the kinetic energy in wind. The ideal or maximum theoretical efficiency (also called power coefficient, C_P) of a wind turbine is the ratio of maximum power obtained from the wind to the total power available in the wind. The factor 0.593 is known as Betz's coefficient. It is the maximum fraction of the power in a wind stream that can be extracted .The C_P of a wind turbine depends on the profile of rotor blades, blade arrangement and setting etc. A designer would try to fix these parameters at its optimum level so as to attain maximum C_P at a wide range of wind velocities.

The thrust force experienced by the rotor (F) and rotor torque(T) are given by

$$F=\frac{1}{2}\rho A_T V^2 \text{ ....[4]}$$

$$T=\frac{1}{2}\rho A_T V^2 R \text{ ....[5]}$$

Where, R is the radius of the rotor.
The ratio between the actual torque developed by the rotor and theoretical torque is termed as the torque coefficient (C_T). Thus,

$$C_T=\frac{2T_T}{\rho A_T V^2 R} \text{ ....[6]}$$

Where, T_T is the actual torque developed by the rotor.
The ratio between the velocity of the rotor tip and the wind velocity is termed as the tip speed ratio (λ). The power developed by the rotor at a certain wind speed greatly depends on tip speed ratio (λ). Thus,

$$\lambda=\frac{2\pi NR}{V}=\frac{\Omega R}{V} \text{ ......[7]}$$

where, Ω is the angular velocity and N is the rotational speed of the rotor.
The power coefficient and torque coefficient of a rotor vary with the tip speed ratio[3].
The tip speed ratio is given by the ratio between the power coefficient and torque coefficient of the rotor.

$$\frac{C_P}{C_T}=\frac{R\Omega}{V}=\lambda \text{ .....[8]}$$

5 Chart

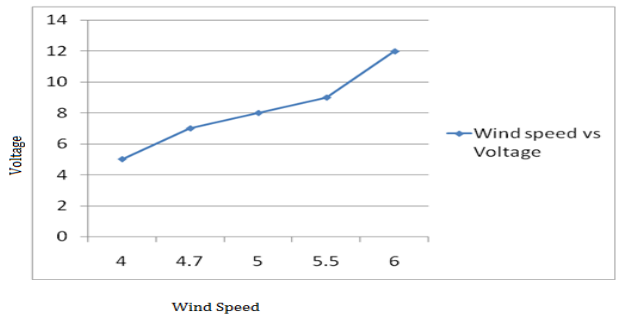


Chart -1 Wind Speed vs Voltage

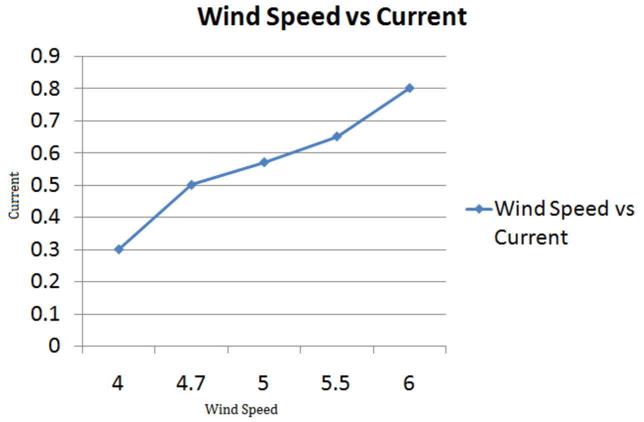


Chart -2 Wind Speed versus Current

6 CONCLUSIONS

The construction of small scale wind turbine for home and domestic application is easy. This performance of small scale wind turbine depend upon wind velocity, air density and which type of generator source. This wind turbine not require to installed only on building it also installed in ground. This wind system has most advantage of direct drive of wind generator system with high efficiency and produce the output at less wind speed. High efficiency and constant voltage obtained because of using boost converter so reliability of system increases. The main purpose of this project is get electricity in rural area and generator load shading area and where the national grid system not reached with high efficiency and economically.] Implementation and Control of Grid Connected

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