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Efficient Household Wind Power Generation with Pitch Yard Control System using Buck Boost Converter

Satheeswaran V, Arun Patrick K, Palani Raja T

Abstract— With increasing concern of global warming and the depletion of fossil fuel reserves, many are looking at sustainable energy solution to preserve the earth for the future generations. Due to the growth of environmental needs, more electricity must be generated from renewable energy sources. Wind power is one of the most clean and abundant sources of energy with no carbon emission. This paper focuses on the society to enhance the usage of domestic wind power generation with Pitch yard control system. It achieved automated changing direction of wind turbine by rotating and moving shaft technique. The buck-boost converter is used to increase or decrease the efficiency of received power based on the power generation in windmill.

Keywords: Buck Boost Converter, Pitch Yard Control System, Wind Turbine.

I. INTRODUCTION

The demand for energy has increased tremendously in the past few decades. As a result, the use of renewable energy sources like solar energy, wind energy etc., is gaining popularity. Thus the Domestic Wind Machines are extensively used in both rural and urban areas to generate electric power from wind energy. Since wind energy can be used for the power generation, many wind machine systems are proposed. Establishing a commercially enabled wind machine systems to obtain effective energy utilization for domestic purpose is not an easy task.

A pitch yard control based windmill system is used domestically nowadays which automatically adjust the wind flow direction using turbine. A domestic pitch yard windmill system is more cost effective than the earlier used wind systems. In Domestic Wind Machines, if the wind speed is low, the output voltage is not sufficient to charge the battery as it is lower than the rated charging voltage of the battery which limits the overall efficiency of the Wind Machine. By implementing a controller based Buck Boost converter, the voltage produced at the lower wind speeds can also be utilized effectively by boosting it to the rated charging voltage of the battery and also if the wind speed is high, the DC output voltage will increase to a maximum value. The converter bucks this high voltage to the steady state battery charging voltage, thereby protecting the battery from over charging voltage. Thus an effective utilization of wind energy can be obtained using Buck Boost converter.

II. LITERATURE SURVEY

There are several hundred thousand windmills in operation around the world. Modern windmills tend to be called wind turbines partly because of their functional similarity to the steam and gas turbines and partly to distinguish them from their traditional forbears [1].

Wind energy was the fastest growing energy technology in the 1990s, in terms of percentage of yearly growth of installed capacity per technology source. The growth of wind energy, however, is not evenly distributed around the world. By the end of 1999, around 69% of the worldwide wind energy capacity was installed in Europe, a further 19% in North America and 10% in Asia and the Pacific [2].

A general comparison of the electricity production costs, however, is very difficult as production costs vary significantly between countries, due to the availability of resources, different tax structures or other reasons. In addition, market regulations can affect the electricity prices in different countries. The competitive bidding processes for renewable power generation in England and Wales (The Non-Fossil Fuel Obligation, D NFFO), however, provides a good comparison of power production prices [3].

Horizontal - axis wind turbines (HAWT) are convectional wind turbines and unlikely the VAWT are not Unidirectional. As the wind changes direction, HAWTs must change direction with it. They must have some means for orienting the rotor with respect to the wind. In a HAWT the generator converts directly the wind which is extracted from the rotor [4].

The rotor speed as well as the power output can be controlled by pitching the rotor blades along their longitudinal axis. A mechanical or an electronic blade pitch control mechanism can be used in order to achieve this. An important advantage for HAWT is that blade pitching acts as a form of protection against extreme wind conditions and over speed. Also the rotor blades can be shaped to achieve maximum turbine

Satheeswaran V, Department of Electronics and Communication Engineering , Nehru Intitute of Technology, Coimbatore , TamiNadu, India. (Email: satheesw@gmail.com)

Arun Patrick K, Department of Computer science and Engineering , Nehru Intitute of Technology, Coimbatore , TamiNadu, India. (Email: arun2pat@gmail.com)

Palani Raja T, Department of Computer science and Engineering, Nehru Intitute of Technology, Coimbatore , TamiNadu, India. (Email: palaniraja1987@gmail.com)

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efficiency, by exploiting the aerodynamic lift to the maximum [5].

Wind turbines operate by the action of the relative wind. Relative wind is a combination of natural wind plus wind caused by rotor motion and the rotor induced flow. The results of the relative wind are the aerodynamic forces which are created on the rotating blades. These aerodynamic forces are called drag and lift forces[6].

The power in the wind is the total available energy per time unit. The power in the wind is converted into the mechanical-rotational energy of the wind turbine rotor, which results in a reduced speed of the air mass. The power in the wind cannot be extracted completely by a wind turbine, as the air mass would be stopped completely in the intercepting rotor area [7].

The tip speed ratio and power coefficient are considerably better than those of the S-rotor. The machine can be mounted on the ground eliminating tower structures and lifting of huge weight of machine assembly. It experience lower velocity wind compared to a tower mounted conventional wind energy conversion system [8].

Airfoil rotor fabrication costs are expected to be reduced over conventional rotor blade costs. The absence of pitch control requirements are synchronous operation may yield additional cost savings. This approach does not appear to be feasible with larger machines [9].

Eliminates yaw control requirement for is rotor to capture wind energy. A dual purpose and relatively allow easier access and serviceability. It requires external mechanical aid for startup [10].

Allow easier access and serviceability. The major advantage of this design is that the rotor blades can accept the wind from any compass. Rotor power output efficiency of a wind energy conversion system is also somewhat lower than that of a conventional horizontal rotor [11].

Wind turbines convert the kinetic energy of the wind to electrical energy by rotating the blades. Greenpeace states that about 10% of electricity can be supplied by the wind by the year 2020[12].

The converter consists of a phase controlled rectifier and a DC/DC boost converter. The rectifier makes the generator AC voltage match the DC voltage while the boost converter keeps the DC voltage constant. The generator's synchronous inductance acts as an AC inductor of boost converter so no extra DC inductor is required [13].

A new two-switch topology, boost-interleaved buck-boost (BOIBB) converter, which can offer significant performance improvements over single-switch buck-boost converters (including flyback, SEPIC, or Cuk topologies) or other two-switch buck- boost converters in universal-input PFC applications. The paper presents an analysis of the converter operation and component stresses, as well as design guidelines. High efficiency (over 93%) throughout the universal-input ac line voltage range is demonstrated on an experimental 100-W, 200-V dc output, universal- input BOIBB PFC rectifier [14].

A new PWM AC-DC convertor with only one switching device is proposed. The control of the AC-DC convertor based on the PWM strategy to make the source current in phase with the source voltage is described, and a simple and practical input filter design is proposed. A comparative study between two proposed types of PWM AC DC convertors and a new PWM AC-DC convertor with only one switching device, is carried out [15].

A family of high-efficiency, high step-up DC-DC converters with simple topologies are proposed in this paper. The proposed converters, which use diodes and coupled windings instead of active switches to realize functions similar to those of active clamps, perform better than their active-clamp counterparts. High efficiency is achieved because the leakage energy is recycled and the output rectifier reverse-recovery problem is alleviated [16].

Considerations of the efficiency variation of a PW synchronous buck-boost converter are made to minimize the power loss. Several new techniques such as channel width regulation, variable threshold voltage, switch activation and gate charge modulation are used. Simulation results show that the efficiency can be improved by more than 15% when the converter works on its light load [17].

III. EXPERIMENTAL SETUP

In this paper we introduce two techniques they are Pitch Yard Control System and Buck Boost Converter.

A. Pitch Yard Control System

In this paper a new technology is introduced for domestic wind power system to change the direction of rotating blades around 360^0 according to the high speed wind direction automatically called Pitch yard control system.

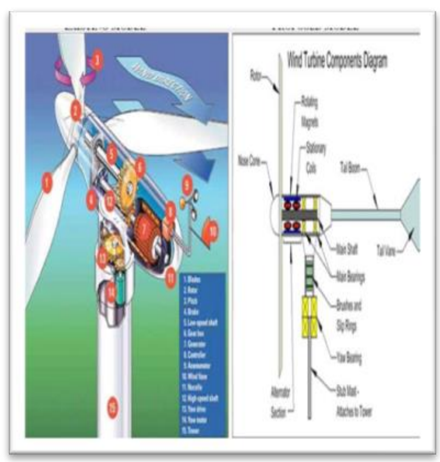
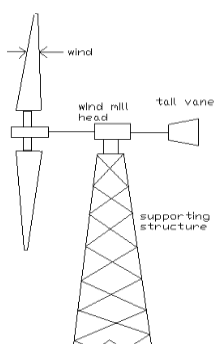


Figure 1: The Structure Comparisons of Existing Model Design and Proposed Model Design.

No. Of days / windd speed in Meter / seconds	Morning	Afternoon	Evening
Day 1	5.62	9.59	10.61
Day 2	9.28	7.84	6.92
Day 3	4.96	7.86	4.37
Average speed			7.47



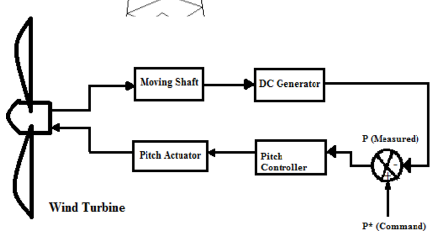


Figure 2: Experimental Setup View

In this system instead of gear box, the rotating shaft is coupled to the DC Generator which starts the power generation. Additionally the combinations of tail boom and tail vane are connected to generator with the connecting shaft to achieve the pitch yard control system.

Figure 3: Working Of Pitch Yard Mechanism.

The working principle of pitch yard system is when the blades are rotate in low speed because of low wind speed in a direction, then the tail vane (pitch controller) start to move from its position towards the direction of high wind speed with the help of displacement of wind on the tail vane. If the wind speed is high at a particular direction then the pitch actuator will locate the system temporarily until the wind speed is low and continues its power generation.

B. Wind Speed

The Anemometer is used to measure the wind speed.

Table 1: Wind speed observation in our college premises

In this system instead of gear box, the rotating shaft is coupled to the DC Generator which starts the power generation. Additionally the combinations of tail boom and tail vane are connected to generator with the connecting shaft to achieve the pitch yard control system.

C. Height of the Tower

The height of the tower is based on the location as well as the wind speed. According to the wind speed observation the tower height is approximately 10 Feet. The Single hole iron pipe width is 1.6 mm thickness which is used as composite material for tower.

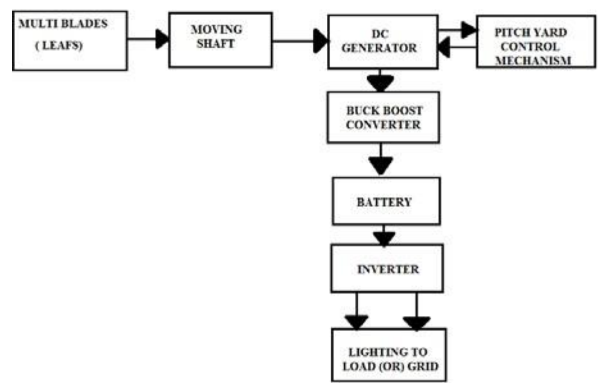


Figure 4: Working Of Domestic Wind Power System with Pitch Yard Control System.

D. Blade Length

The length of the blade is about 20% of height of the tower. In this prototype aluminium is used as composite material.

E. DC Generator

The Permanent Magnet DC generator is used to convert Mechanical energy into Electrical energy.

Power 150 W
Voltage 48 V DC
Current 4 Amp
HP 1
RPM 1500
Table 3.2 DC Generator Observations

F. Battery

1) Type – Sealed Lead – Acid battery
2) Range – 12 V / 7.2 Ah
3) Charge Parameter – Constant Voltage Charge with regulation 27^o C
4) Stand by Use – 13.6 V – 13.8 V – 2.16 Amps
5) Cycle Use – 14.1 V – 14.4 V – 2.16 Amps
6) Maximum Initial Current – 1.4 A

G. Inverter

1) Power – 200 W
2) DC – 12 V
3) AC – 220 V
4) I – 4 Amps
5) Input – DC
6) Output – AC

H. Power Efficiency

P = k Cp 1/2 ρ A V3
Where,
P = Power output, kilowatts
Cp = Maximum power coefficient, ranging from 0.25 to 0.45, dimension less (theoretical maximum = 0.59)
ρ = Air density, lb/ft3
A = Rotor swept area, ft2 or π D2/4 (D is the rotor diameter in ft, π = 3.1416)
V = Wind speed, mph
k = 0.000133 A constant to yield power in kilowatts. (Multiplying the above kilowatt answer by 1.340 converts it to horse-power [i.e., 1 kW = 1.340 horsepower]).

I. Buck & Boost Converter

A buck converter is a step-down DC to DC converter. Its design is similar to the step-up boost converter, and like the boost converter it is a switched- mode power supply that uses two switches (a transistor and a diode), an inductor and a capacitor. The simplest way to reduce the voltage of a DC supply is to use a linear regulator (such as a 7805), but linear regulators waste energy as they operate by dissipating excess power as heat. Buck converters, on the other hand, can be remarkably efficient (95% or higher for integrated circuits), making them useful for tasks such as converting the main voltage in a computer (12 V in a desktop, 12-24 V in a laptop) down to the 0.8-1.8 volts needed by the processor.

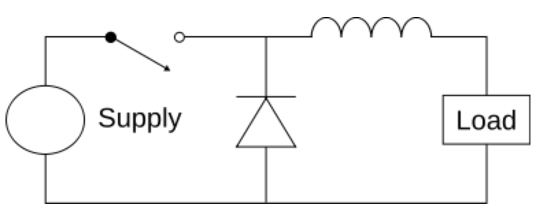


Figure 5: Schematic diagram of Buck Converter

A boost converter (step-up converter) is a DC- to-DC power converter with an output voltage greater than its input voltage. It is a class of switched-mode power supply (SMPS) containing at least two semiconductor switches (a diode and a transistor) and at least one energy storage element, a capacitor, inductor, or the two in combination. Filters made of capacitors (sometimes in combination with inductors) are normally added to the output of the converter to reduce output voltage ripple.

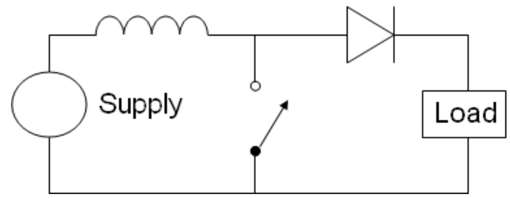


Figure 6: The basic schematic of a boost converter

The buck boost converter is a hybrid device which performs combined function of both buck and boost converter. The buck–boost converter is a type of DC-to-DC converter that has an output voltage magnitude that is either greater than or less than the input voltage magnitude. Two different topologies are called buck–boost converter. Both of them can produce a range of output voltages, from an output voltage much larger (in absolute magnitude) than the input voltage,
down to almost zero.

J. DC Converters

DC-DC converters are electronic devices used whenever we want to change DC electrical power efficiently from one voltage level to another. They are needed because unlike AC, DC can't simply be stepped up or down using a transformer. In many ways, a DC- DC converter is the DC equivalent of a transformer.

K. Inverting Topology

The output voltage is of the opposite polarity than the input. This is a switched- mode power supply with a similar circuit topology to the boost converter and the buck converter. The output voltage is adjustable based on the duty cycle of the switching transistor. One possible drawback of this converter is that the switch does not have a terminal at ground; this complicates the driving circuitry. Neither drawback is of any consequence if the power supply is isolated from the load circuit (if, for example, the supply is a battery) because the supply and diode polarity can simply be reversed. The switch can be on either the ground side or the supply side.

A buck (step-down) converter followed by

A boost (step-up) converter. The output voltage is of the same polarity of the input, and can be lower or higher than the input. Such a non-inverting buck-boost converter may use a single inductor which is used for both the buck inductor and the boost inductor.

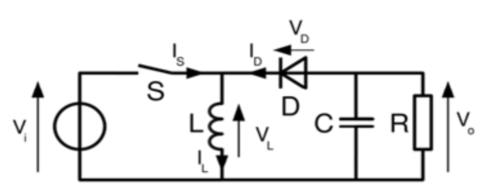


Figure 7: Schematic of a buck–boost converter.

The basic working principle of the buck–boost converter is fairly simple. While in the On-state, the input voltage source is directly connected to the inductor (L). This results in accumulating energy in L. In this stage, the capacitor supplies energy to the output load. While in the Off-state, the inductor is connected to the output load and capacitor, so energy is transferred from L to C and R.

Compared to the buck and boost converters, the characteristics of the buck– boost converter are mainly,

1. Polarity of the output voltage is opposite to that of the input
2. The output voltage can vary continuously from 0 to α(for an ideal converter).

The output voltage ranges for a buck and a boost converter are respectively 0 to Vi and Vi to α.

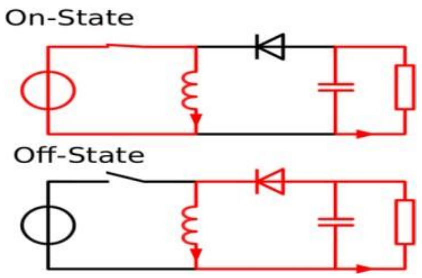


Figure 8 The two operating states of a buck–boost converter

IV. RESULTS

A. Expected Outcome

S.NO	WIND SPEED (MPH)	POWER GENERATED (WATTS)
1	13	92
2	17	207
3	18	246
4	19	290

Table 2: Power Efficiency

B. Efficiency Curve

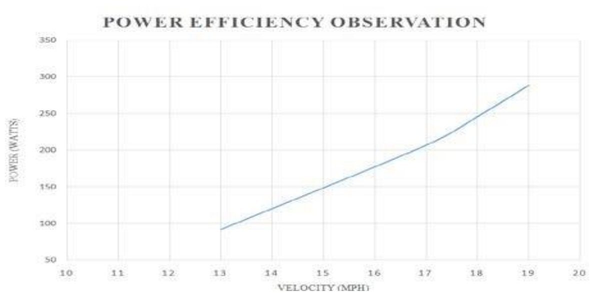


Figure 9: Power Efficiency

V. CONCLUSION

The proposed system based on pitch yard control system automatically changes the direction according to the wind speed. By implementing a controller based buck boost converter, the voltage produced at lower wind speed can also be utilized effectively by boosting it to the rated charging voltage of the battery. Hence the voltage at any wind speed can be effectively utilized and the efficiency of the proposed system is 20% higher than the existing system.

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