



Power Generation Using Magnetic Levitation Windmill

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ABSTRACT: This project dwells on the implementation of an alternate configuration of a wind turbine for power generation purposes. Using the effects of magnetic repulsion, spiral shaped wind turbine blades will be fitted on a rod for stability during rotation and suspended on magnets as a replacement for ball bearings which are normally used on conventional wind turbines. Power will then be generated with an axial flux generator, which incorporates the use of permanent magnets and a set of coils.

KEYWORDS: Wind energy, magnetic levitation, magnets.

I. INTRODUCTION

Renewable energy is generally electricity supplied from sources, such as wind power, solar power, geothermal energy, hydropower and various forms of biomass. These sources have been coined renewable due to their continuous replenishment and availability for use over and over again. It is estimated that renewable sources might contribute about 20% – 50% to energy consumption in the latter part of the 21st century. Facts from the World Wind Energy Association estimates that by 2010, 160GW of wind power capacity is expected to be installed worldwide which implies an anticipated net growth rate of more than 21% per year.

This project focuses on the utilization of wind energy as a renewable source. Unlike the traditional horizontal axis wind turbine, this design is levitated via maglev (magnetic levitation) vertically on a rotor shaft. This maglev technology, which will be looked at in great detail, serves as an efficient replacement for ball bearings used on the conventional wind turbine and is usually implemented with permanent magnets. This levitation will be used between the rotating shaft of the turbine blades and the base of the whole wind turbine system. The conceptual design also entails the usage of spiral shaped blades and with continuing effective research into the functioning of sails in varying wind speeds and other factors, an efficient shape and size will be determined for a suitable turbine blade for the project. With the appropriate mechanisms in place, we expect to harness enough wind for power generation by way of an axial flux generator built from permanent magnets and copper coils. The arrangement of the magnets will cultivate an effective magnetic field and the copper coils will facilitate voltage capture due to the changing magnetic field. The varying output voltage obtained at this juncture will then be passed through a DC-DC converter to achieve a steady output DC voltage.

II. SYSTEM MODEL AND HARDWARE DESIGN

This section introduces and provides a brief description of the major components and factors that will contribute to an efficiently functioning wind turbine. These factors are wind power, the generator, magnet levitation and the DC-DC converter. Later sections will provide an in-depth look into the essence of each factor and its function and importance to the overall operation of the vertical axis wind turbine.

A. Wind Power

Undoubtedly, the project's ability to function is solely dependent on the power of wind and its availability. Wind is known to be another form of solar energy because it comes about as a result of uneven heating of the atmosphere by the sun coupled with the abstract topography of the earth's surface. With wind turbines, two categories of winds are



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relevant to their applications, namely local winds and planetary winds. The latter is the most dominant and it is usually a major factor in deciding sites for very effective wind turbines especially with the horizontal axis types.

B. Generator

The basic understanding of a generator is that it converts mechanical energy to electrical energy. Generators are utilized extensively in various applications and for the most part have similarities that exist between these applications. However the few differences present is what really distinguishes a system operating on an AC motor from another on the same principle of operation and likewise with DC motors. With the axial flux generator design, its operability is based on permanent magnet alternators where the concept of magnets and magnetic fields are the dominant factors in this form of generator functioning. These generators have air gap surface perpendicular to the rotating axis and the air gap generates magnetic fluxes parallel to the axis. In further chapters we will take a detailed look into their basic operation and the configuration of our design.

C. Magnetic Levitation

Also known as maglev, this phenomenon operates on the repulsion characteristics of permanent magnets. This technology has been predominantly utilized in the rail industry in the Far East to provide very fast and reliable transportation on maglev trains and with ongoing research its popularity is increasingly attaining new heights. Using a pair of permanent magnets like neodymium magnets and substantial support magnetic levitation can easily be experienced. By placing these two magnets on top of each other with like polarities facing each other, the magnetic repulsion will be strong enough to keep both magnets at a distance away from each other. The force created as a result of this repulsion can be used for suspension purposes and is strong enough to balance the weight of an object depending on the threshold of the magnets. In this project, we expect to implement this technology for the purpose of achieving vertical orientation with our rotors as well as the axial flux generator.

D. DC-DC Conversion

In order to begin the analysis of DC-DC converters it is important to first understand the concept behind a converter. Over the years, alternating current has been the common choice of power supply. AC is popular because the voltage can be easily stepped up or down using a transformer. Due to the inherent properties of a transformer, DC voltage cannot be altered using this type of equipment. Transformers operate due to a changing magnetic field in which the change in magnetic flux induces a current. Direct current cannot provide a changing magnetic field therefore a transformer with an applied DC input would only produce heat. The concept of DC-DC conversion emerged after the development of fast switching transistors. By varying the duty cycle of the pulse that is applied to the gate of the transistor for switching, these converters can buck or boost the voltage as if it were a DC transformer. When accurate feedback is applied to this type of circuit, the converter will not only transform a supply voltage to the desired output but also maintain it given a varying input. These qualities of DC-DC converters are the foundation of the circuit that will be chosen for this project

E-Phase Connections

A 3-phase connection implies that a generator produces three voltages each with their own phase angle. A major advantage of the 1-phase connection is that the output allows the current to peak a different times allowing for smaller more frequent peaks as opposed to one large peak produced in a single phase connection. These smaller current peaks produce less vibration as the generator spins. Less vibration leads to less wear on the parts of the generator such as the bearings.

Types of Connections

There are two basic 3-phase connections known as wye and delta. During analysis we may assume a balanced condition, which refers to all three voltages having equal magnitude and being displaced by 120 degrees. We made use of six coils in our generator allowing for two coils per phase. Coils opposite each other in the physical design are connected in series in turn summing the voltages from each coil to produce a phase voltage. The circuit diagrams for the wye and delta connections to the rectifier are shown below.

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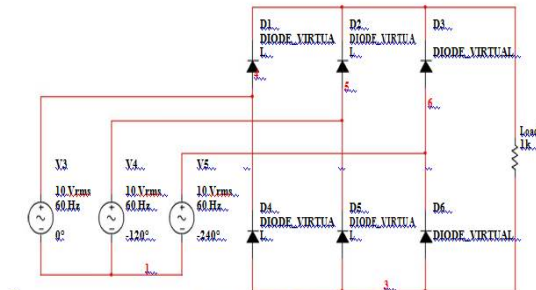


Figure V.8 - Wye Connection

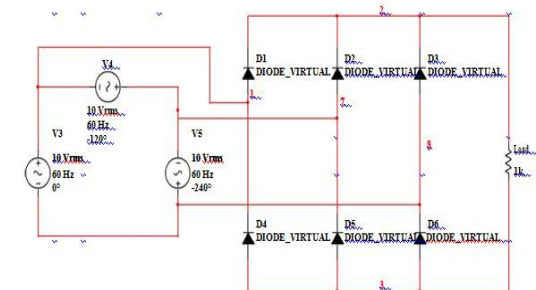
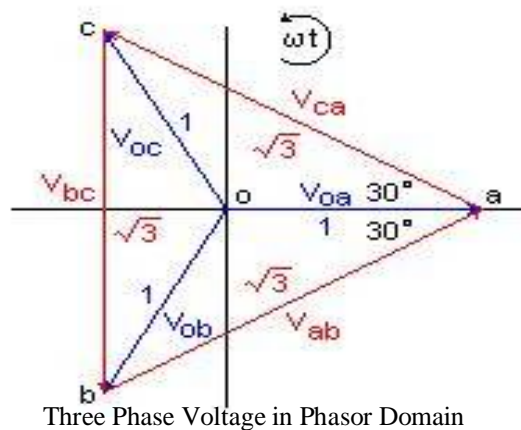


Figure V.9 - Delta Connection

Three voltages, equal in magnitude, following a sequence a-b-c. Using this convention 'a' leads 'b' by 120 degrees and 'b' in turn leads 'c' by 120 degrees]. Each phase voltage is superimposed upon the other in the figure below, illustrating the phase shift.

The phases are displaced both in the time and the phasor domain. The phasor domain is shown below.



The voltage equations can be written in phasor form. Each voltage phase with respect to the neutral is the phase voltage amplitude shifted 120 degrees.



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III. DESIGN AND FORMULATION

1) Power Coefficient Analysis: This hypothesis is reproduced to show the relationship between the power coefficient (C_p) and the wind speed, Which expresses the basic theory of the Savonius wind machine. Principally the power that the rotor can extract from the wind (P_w) is less than the actual available from the wind power (P_a). In order to calculate the performance of this wind machine, its configuration is essentially important.

a) According to the Kinetic Energy,

$$KE = \frac{1}{2} mv^2$$

b) The available power, P_a from the wind is:

$$P_a = \frac{1}{2} mv^2 \text{ When } m = \rho Av \\ P_a = \frac{1}{2} \rho Av^3$$

c) The power coefficient C_p is given by:

$$C_p = P_w / P_a$$

Therefore: Power extracted from the wind,

$$P_w = C_p \times P_a \\ = C_p \times \frac{1}{2} \rho Av^3$$

Power by air impact = $c_p \times \frac{1}{2} \times \text{density} \times \text{area} \times v^3$

This is the standard wind equation that is used in this documentation.

d) To Calculate Area (A) =?

$$A = (\text{power} \times 2) / (C_p \times \text{density} \times v^3) \\ \text{Where, } C_p = P_w / P_a = 3$$

e) To Calculate Shaft Rotation ($\dot{\omega}$) =?

The equation below is used whereby the radius value R ($D/2$) is manipulated to obtain w . It is assumed that the value of X (tip speed ratio) is equal to 1, to eliminate X in the equation below.

$$X = R \omega / V$$

ω = rotational speed (rads/s);

R = radius of rotor (m);

V = average wind speed, assume 10 m/s.

$\omega = V/R$, R is varied between 0.2 and 0.55 meters, a reasonable range baring in mind the speed of rotation.

To calculate the height (h) =?

The equation below is used to calculate h:

Area (A) = height (h) x diameter (D)

VI. CONCLUSION

Over all, the magnetically levitated vertical axis wind turbine was a success. The rotors that were designed harnessed enough air to rotate the stator at low and high wind speeds while keeping the center of mass closer to the base yielding stability. The wind turbine rotors and stator levitated properly using permanent magnets which allowed for a smooth rotation with negligible friction. At moderate wind speeds the power output of the generator satisfied the specifications needed to supply the LED load. Lastly the SEPIC circuit operated efficiently and to the specifications that were slated at the beginning of the circuit design. After testing the project as an overall system we found that it functioned properly but there are many things that can be improved upon. The generator itself had some design flaws which we feel limited the amount of power it could output. These flaws start at the coils which were initially made too thick and limited how close the magnets attached to the stator could be positioned from each other. In terms of large scale power production, vertical axis wind turbines have not been known to be suitable for these applications. Due to the overall structure and complexity of the of the vertical axis wind turbine, to scale it up to a size where it could provide the amount of power



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to satisfy an commercial/industrial park or feed into the grid would not be practical. The home for the magnetically levitated vertical axis wind turbine would be in residential areas. Here it can be mounted to a roof and be very efficient and practical. A home owner would be able to extract free clean energy thus experiencing a reduction in their utility cost and also contribute to the “Green Energy” awareness that is increasingly gaining popularity

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