Construction of a Prototype Vertical Axis Wind Turbine Phone Charger Using Permanent Magnet Alternator

Ormin Bundega Joseph, Sachia Simon Bemsen

***Abstract*— In this project, a prototype Savonius vertical axis wind turbine potential as a means of energy generation in charging Nickel-Metal phone batteries was considered. The wind turbine was designed and constructed using permanent magnet alternator. It was tested using a blower and a digital multimeter. The wind turbine was able to produce power in the range of 0.00134-4.19mW and a maximum voltage output of 1.25V at the highest blower speed. It can equally work efficiently when installed or placed in high wind speed sites.**

***Index Terms*— Wind Turbine, Renewable energy, Magnetic Induction, Alternator.**

I. Introduction

In recent years, awareness in renewable energy has conspicuously improved due to global greenhouse gasses. This in turn promotes research in renewable energy source particularly in wind energy. The state of energy crisis in Nigeria with respect to electric power generation and distribution has been dependable for many problems which include closure of most industries, low productivity and other adverse macroeconomic implications, (Onawumi et al., 2011).

About 75% of people living in sub-Sahara part of Nigeria do not have access to electricity. Even those that are connected to the grid still have energy cuts. This populace uses fuel or diesel-generators (non-renewable energy) for charging of batteries for effective communication. With scarcity of resources, most of them cannot withstand the high cost of maintaining and buying fuel for their generators to charge their phone batteries for effective communication, (Legros et al., 2009).

Mobile phone been one of the basic means of communication there is need for constant charging of the phone batteries.

With the abundance of renewable energies like wind in Nigeria especially in the Northern States, power can be generated by a wind turbine which is very easy to construct and maintain with little or no pollution. This will decrease the need for expensive power generators that we normally use in charging our phone batteries that produces a lot of carbon dioxide which is contributing to the destruction of the Ozone layer.

The development of wind turbine started since 200BC Percia (present-day Iran) but it was until 250 AD that the use of wind mills became more popular. It was used to drive machineries.In the 7th century, the first known practical windmills were built in Sistan, a region between Afghanistan and Iran. These were vertical axle windmills which had long vertical drive shafts with rectangular blades. It was made of six to twelve sails covered in reed matting or cloth material used to grind corn and draw up water which was used in the grist milling and sugarcane industries.The first electricity generating wind turbine was a battery charging machine installed in July, 1887 by Scottish academic James Blyth to light his holiday home in Marykirt, Scotland.There are three types of wind turbines viz; Horizontal Axis Wind Turbines, Vertical Axis Wind Turbines and the Unconventional types. The horizontal-axis wind turbines (HAWTs) are also known as wind-axis machines, the axis of rotation of these machines is parallel to the direction of the wind. Vertical axis wind turbines (VAWTs) have the main rotor shaft arranged vertically. The key advantage of VAWTs over HAWTs is that the turbine does not need to be pointed into the wind to be effective. This is an advantage on sites where wind direction is highly variable.Other subtypes of VAWTs include; Darriues wind turbine, Giromill, Savonius turbine and Parallel turbine. (https://en.wikipedia.org/wiki/Wind_turbine)

Gupta (1978) designed and developed 1kW vertical axis wind generator at wind speed of 6.9m/s. It is a two-bladed Darrieus type design with combination of vertical and inclined blades. Overall efficiency of 40% was assumed. The diameter of the wind turbine was selected as 4meters, blade chord as 0.2meters, blade weight as 4.5kg/m, length of each blade segment as 1.6meters, angle of inclined blade with horizontal as 28^0, and rotor speed 160rpm.

Sarki (1986) designed a vertical axis windmill that has a rated power of about 45W at a rated wind speed of 4.3m/s in Zaria. The power so generated is to drive a water pump to a 10m head tank and at a pumping rate of about 0.4litre/sec. The design consists of vertical axis rotor with two blades attached to intercept wind. In this design no arrangement was made for speed control.

Taylor (1990) designed a horizontal-axis windmill to generate a maximum power of 8kW of electricity at a rated wind speed of 10.83m/s in Jos. The design has the horizontal-axis rotor consisting of two blades mounted on the rotor solid shaft. The design incorporated a tail vane to aid control for the blades to intercept winds if it changes direction. However, no arrangement was made for speed control in case of wind speed much higher than the rated speed.

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The vertical axis wind turbine phone charger is designed with one principal aim; to charge our Nickel-Metal Hybride (NiMH) phone batteries in order to enhance high level of communication in both urban and rural areas of Nigeria.

II. MATERIALS AND METHOD

Materials

The vertical –axis wind turbine was designed using a PVC disc, a PVC pipe, aluminum plates, 4 rare earth disc magnets (Neodymium), 2 ball bearings, 38-gauge enameled copper wire, wooden frame and a small piece of corrugated card board.

Methodology

The wooden frame was made in form of a quadrant of length 42cm and breadth 30cm. A hole was drilled on the center of the base lengths of diameter 6cm where the ball bearings are fitted. The PVC pipe was cut into an open surface cylinder of diameter 2.4cm and 34cm long to make the shaft of the turbine. The aluminum plate was cut into half the surface area of an open cylinder of height 24cm and radius 22cm which was used to make three blades. The three blades were fitted on the shaft at an angle of 120 degrees between the blades. The ends of the shaft were fitted into the top and bottom bearings with the shaft extending at the top bearing at about 4cm.

The PVC disc was used to make the stator. It contains the 8 coils arranged at 45 degrees to each other and was screwed on the top of the frame with a drilled hole of diameter 6cm on the center of the disc. The assembling of the DVD disk and the four-disc magnet to make the rotor was done. The disk has a diameter of 12cm and a hole diameter 2.5 was drilled on it. The four-disc magnets were mounted on the DVD disk at an angle of 90 degrees to each other, after making sure that the magnets were facing either north or south by passing each of the magnets on the coils to have the same polarity.

The rotor containing the magnets was then fitted on the extended shaft close to the coils about 3mm above it using hot glue.

Fig. 1.1 Pictorial View of a Prototype Vertical Axis Wind Turbine Phone Charger.

Block Diagram of Wind Power Generation System

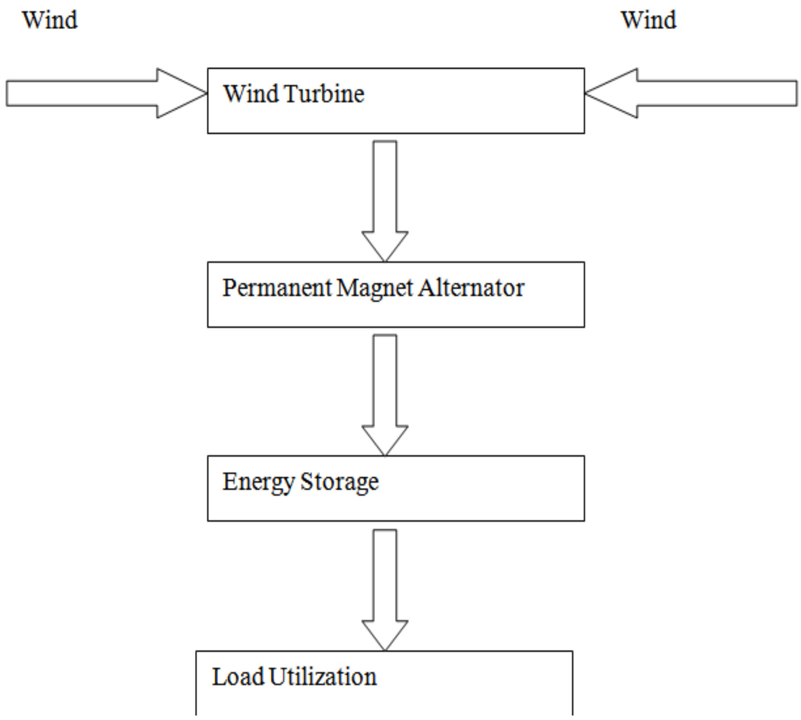

Fig. 1.2: Block diagram of wind power generation

Electromagnetic Induction

The permanent magnet alternator in the turbine uses the principle of electromagnetic induction to convert surplus energy of motion from the turbine into electrical energy. When a magnetic field flux is moved relative to a stationary series of winded coils, the magnetic field flux will induce an electromotive force (emf) or voltage into the wire. The strength of the electromotive force or its voltage will be proportional to the number of turns of the coils. This is illustrated by Faraday's law of electromagnetic induction which states that ''Any change in the magnetic environment of a coil of wire will cause a voltage (emf) to be induced in the coil. No matter how the change is produced, the voltage will be generated, the change could be produced by changing the magnetic field strength, moving a magnet towards or away from the coil, moving the coil into or out of the magnetic field and rotating the coil relative to the magnet''.(https://physics.ucf.edu/~roldan/classes/Chap29_PHY2049.pdf).

Voltage generated, $(emf) = -\frac{\boldsymbol{N\Delta(BA)}}{\boldsymbol{\Delta t}}$

Where $\boldsymbol{N}$ = Number of turns, $\boldsymbol{B}$ = External magnetic field, $\boldsymbol{A}$ = Area of coil

The minus sign denoted Lenz's law.

Charge Controller Circuit

A simple charge controller circuit was used to convert the AC voltage generated to DC voltage and a set of parallel capacitors to store and increase the DC voltage output. The circuit consists of:

i. A Germanium diode
ii. Capacitors

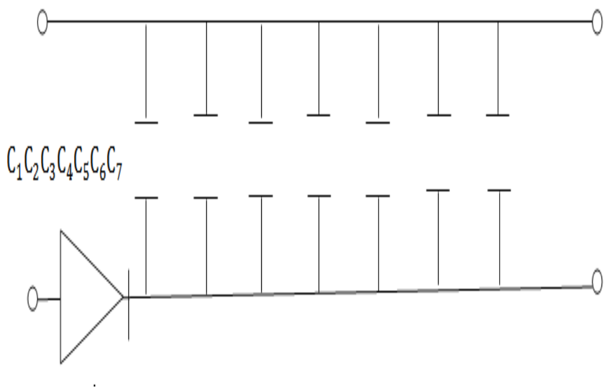

Fig. 1.3 Charge controller Circuit

Where $C_1 = C_2 = C_3 = C_4 = C_5 = C_6 = 700nF$, $C_7 = 10\mu F$

Wind Turbine Power

The power generated from this wind turbine can be expressed as:

$$\boldsymbol{P = IV}$$

Where $\boldsymbol{P}$ = Power in Watts, $\boldsymbol{I}$ = Current in amperes, $\boldsymbol{V}$ = Voltage in Volts

According to Ohm's law, the potential difference (voltage) across an ideal conductor is proportional to the current through it. That is, $\boldsymbol{V = IR}$

Therefore, the power generated can be written as:

$$\boldsymbol{P = \frac{V^2}{R}} \quad (1)$$

By utilizing equation (1), the power generated from the wind turbine is computed at different number of revolutions per minute since the resistance in the copper wire used is constant, $\boldsymbol{R = 373\Omega}$.

III. RESULTS

In the previous section, the power and the voltage output from the wind turbine was computed from the number of revolutions per minute of the wind turbine. Table 4.1 and table 4.2 shows the power generated and the voltage output at different revolutions per minute.

Table 4.1. The voltage output at different number of revolutions per minute of the wind turbine.

Number of revolutions per minute	**Voltage (V)**
526.2	0.070
532.9	0.141
630	0.372
720	0.884
750	1.046
820	1.250

Table 4.2. The power generated at different number of revolutions per minute of the wind turbine

Number of revolutions per minute	**Power (mW)**
526.2	0.0013
532.9	0.0530
630	0.3700
720	2.0900
750	2.9300
820	4.1900

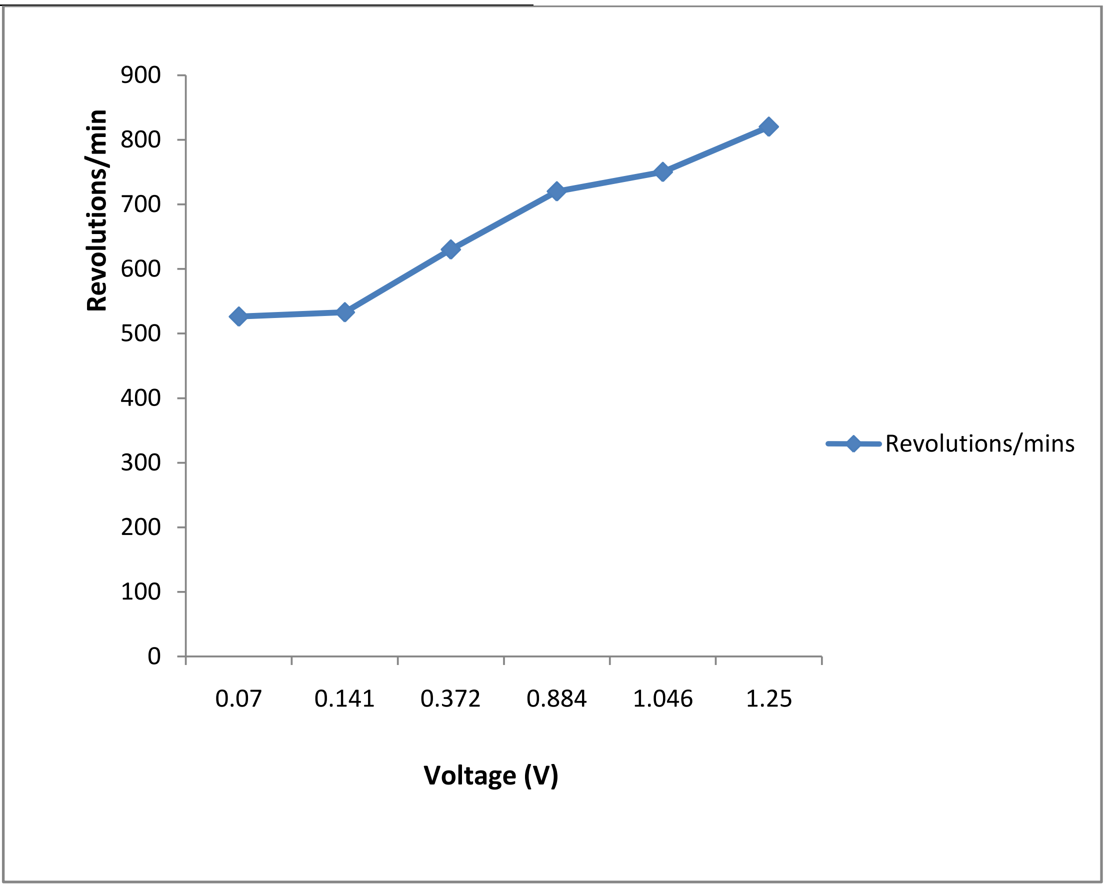

Fig. 4.1 A graph of the number of revolutions per minute against voltage output

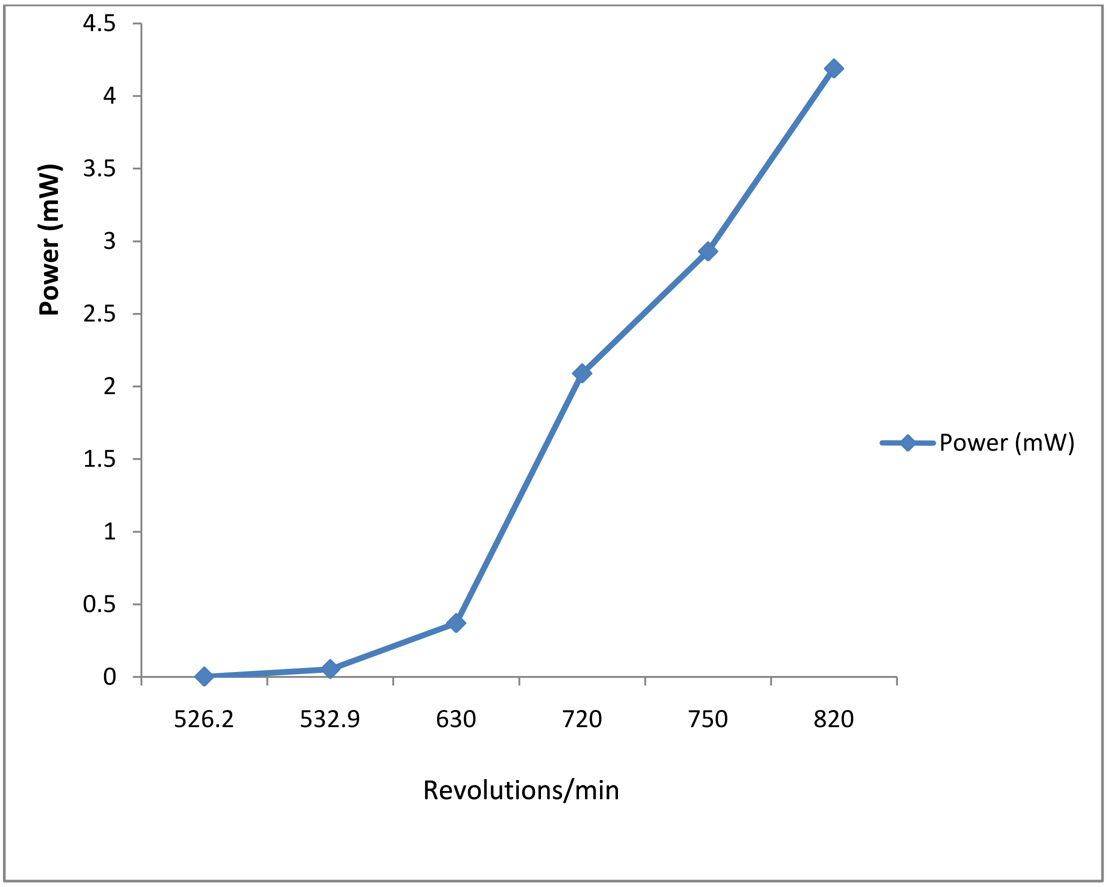

Fig. 4.2 A graph power against the number of revolutions per minute.

IV. ANALYSIS

The power available and the voltage output is dependent on the speed of wind and hence on the number of revolutions per minute of the wind turbine. The results from table 4.1, table 4.2 and the graphs in fig. 4.1 and fig. 4.2 clearly shows that as the number of revolutions per minute increases, the power and the voltage output increase in the range of 0.0013-4.19mW and 0.07-1.25V respectively. Therefore, owing to this limitation faced by this vertical axis wind turbine, places with higher wind speed takes the center stage as the potential sites for building wind turbine.

V. RECOMMENDATIONS

In future research, efforts should be made to increase the area of the wind turbine in order to increase the power output thereby increasing the range of appliances that can be powered with the wind turbine and observe the effects on the system.

Also, efforts should be made in educating individuals, private and public organizations on the benefits of designing large wind turbines which has little or no pollution in the environment, most especially places with high wind speed.

VI. CONCLUSION

From this project we can conclude that it would be possible to use the wind turbine asan alternative means of generating electricity capable of charging our mobile phones batteries to enhance communication.

The project was designed in stages, with each aimed to achieve the design specifications as far as possible. The project was a success but however be improve upon for better results. The only drawback being that of having to use an external means (blower) to increase the speed of the wind to know the performance of the turbine when it is been installed at places where the wind speed is high and constant.

REFERENCES

[1] Gupta, R.P et al (1978), Development of 1KW Vertical Axis Wind Generator, Proceedings of The ISES Cong., New Delhi, Vol. 3, pp. 1803-1808.
[2] https://physics.ucf.edu/~roldan/classes/Chap29_PHY2049.pdf
[3] https://en.wikipedia.org/wiki/Wind_turbine
[4] https://www.instructables.com/Building-a-Vertical-Axis-Wind-Turbine-VAWT-/
[5] Legros et al (2009). ‘‘Wind Energy Conversion Systems’’. International Association for Energy Economics Vol. 4 pp 17-21
[6] Onawumi, A. S et al (2011). ‘‘A review of Savonius wind turbine as a source of energy generation in Nigeria’’. International Journal of Emerging trends in Engineering and Development, Vol. 3 pp 325-333, ISSN 2249-6149
[7] Sarki, M. A (1986). ‘‘Design of a Vertical-Axis Windmill for Rural use’’. M.Sc thesis, Mechanical Engineering Department, Ahmedu Bello University, Zaria.
[8] Taylor, B. O (1990). ‘‘Design of an 8kW Horizontal-Axis Windmill to Generate Electricity in a Secondary School, located in an isolated Rural area’’. B. Eng. Project, Mechanical Department, Ahmedu Bello University, Zaria.