BERKELEY PUBLICATION
AND RESEARCH INTERNATIONAL

03.31.2020

Journal of Pure and Applied Science Vol. 12 No. 9

WIND SPEED VARIATION FOR A VERTICAL WIND GENERATOR AND ITS EFFECTS IN A TROPICAL CLIMATE WEATHER CONDITION

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ABSTRACT

Wind energy is one of the promising renewable energy sources in Distributed power Generation. But due to its inconsistency in the variation and fluctuation of the environmental wind velocity, the power generated by the wind turbine is not constant. This variation in the wind speed leads to the power quality problems in its output Voltage/Current wave forms. In this paper, the effect of wind speed variation that resulted in the instability of the wind power output in relation to the power quality is presented. However, a four months wind Speed Data for a 1.5KW permanent magnet synchronous generator (PMSG) wind turbine was measured at Universiti Putra Malaysia in order to ascertain the reliability of site for the

Introduction:

Nowadays, the interest of wind energy power generation in urban and rural areas are increasingly accepted by individuals and researchers, because of the availability of the wind velocity, which is free of charge natural sources of energy in every environment. The wind power generation is a clean energy, free from pollutions that reduce the global warming and carbon dioxide (CO_2) to the atmosphere in the whole universe. However, due to the frequent intermittent nature of the wind speed especially in a tropical climate weather condition where the winds

installation of the wind turbine. The implemented model of a 1.5KW variable wind turbine (PMSG) is simulated in MATLAB/SIMULINK soft ware environment; and the average wind speed Data is analyzed.

Index term- *Wind speed, PMSG, and power quality.*

Speed cannot be predictable. The generation of wind power becomes very difficult because of the uncertainty of the wind velocity available within the wind mills or wind blades. Moreover, due to this variation in wind speed, the generated power output produced by the wind turbine is affected, which leads to power quality problems in the output Voltage/current wave forms by the wind turbine generator. As a result of this power quality problems manifested by the wind generator, Voltage sags, flickers, and harmonics and inter harmonics are created within the generated power supply. Mostly, a permanent magnet synchronous generator (PMSG) is employed in the vertical axis wind turbine for power generation due to its robustness, reliability and requires no any additional DC source supply for its excitation system [1], [2].The wind power generation total capacity were predicted to be 175,000MW by this year 2012 [3]. In this paper, the effect of wind speed for a 1.5KW wind turbine system is to be studied. The wind turbine system is simulated in MATLAB. Also a wind velocity data for four months with different variation of wind speed are analyzed in this paper.

A Simple Model of Wind turbine System.

The process of wind turbine energy is the conversion of kinetic energy due to the wind available within the blades, and converting the kinetic energy in to mechanical energy by a prime mover, which produces a torque at its output. This kinetic energy developed by the wind turbine, its magnitude depends on the air density and the wind velocity within the vicinity of the wind blades [4]. The power generated by wind turbine is given by an expression below.

$$P_m = C_p(\lambda, \beta)\rho A \frac{1}{2} V_{wind}^3 \qquad (1)$$

Where,

P_m = Output mechanical power by the wind turbine (Watts).

C_p = Performance coefficient of the wind turbine.

ρ Is the atmospheric air density within the blades in (Kg/m^3).

A = is the swept area of the turbine in (m^2).

V_{wind} = the tip speed ration of the rotor blade tip speed to wind speed.

β Is the blade pitch angle in (degree).

From equation (1), $C_p(\lambda,\beta)$ can be expressed by the general equation:

$$C_p(\lambda,\beta) = C_1\left(\frac{C_2}{\lambda_i} - C_3\beta - C_4\right)e^{-\frac{C_5}{\lambda_i}} + C_6\lambda \quad (2)$$

With, $\frac{C_1}{\lambda_i} = \frac{1}{\lambda_i} + 0.08\beta - \frac{0.035}{\beta^3+1}$ λ_i= 1/λ+0.08β- 0.035/β^3+1 (3)

Here, the range of values of C are, C_1=0.5176, C_2= 116 C_3 =0.4, C_4 =5, C_5 =21 and C_6 = 0.0068. The $C_p - \lambda$ characteristic, for different values of the pitch angle β, fig 1 shows the characteristics curves of C_p against λ. For maximum values of $C_p\left(C_{p\max} = 0.48\right)$ and β= 0 degree, while λ= 8.1[5].

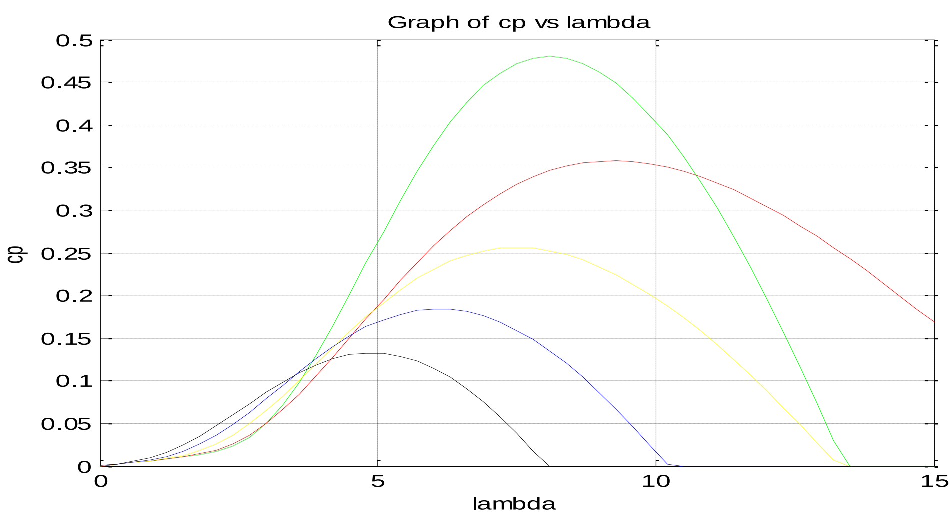

Fig 1 Performance coefficient and tip speed ratio.

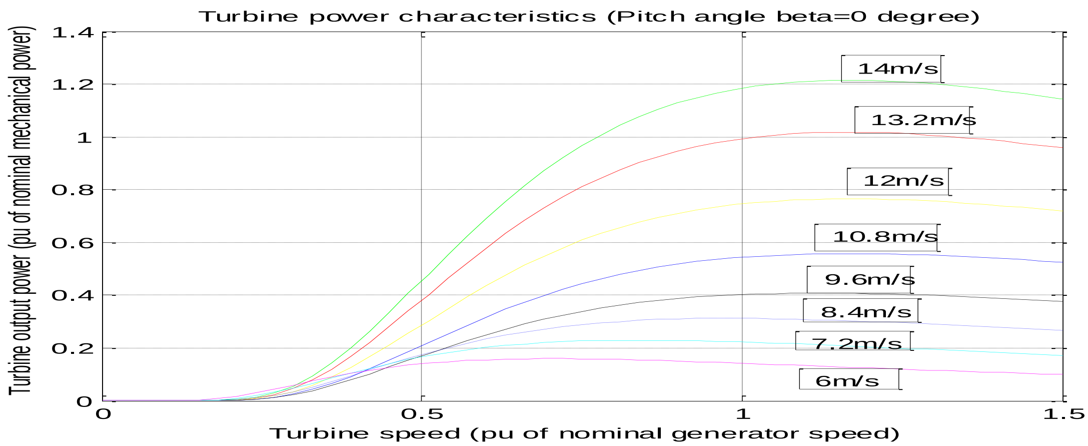

Fig 2 Turbine speed and turbine output power.

SIMULATION STUDY

In this part, a permanent magnet synchronous generator of 1.5KW capacity is modeled and simulated in the famous MATLAB soft ware environment. The behavior of the wind turbine output voltage is obtained in figure 4, the simulation result shows the effect of the wind speed variations due to the non availability in the wind velocity at the site of the installed 1.5KW wind turbine system. As a result of this insufficient output voltage/current wave form, the system suffered a serious distortion which resulted in the power quality issues regarding the output voltage/current of the wind turbine. Figure 3 depicts the overall simulation of the proposed study.

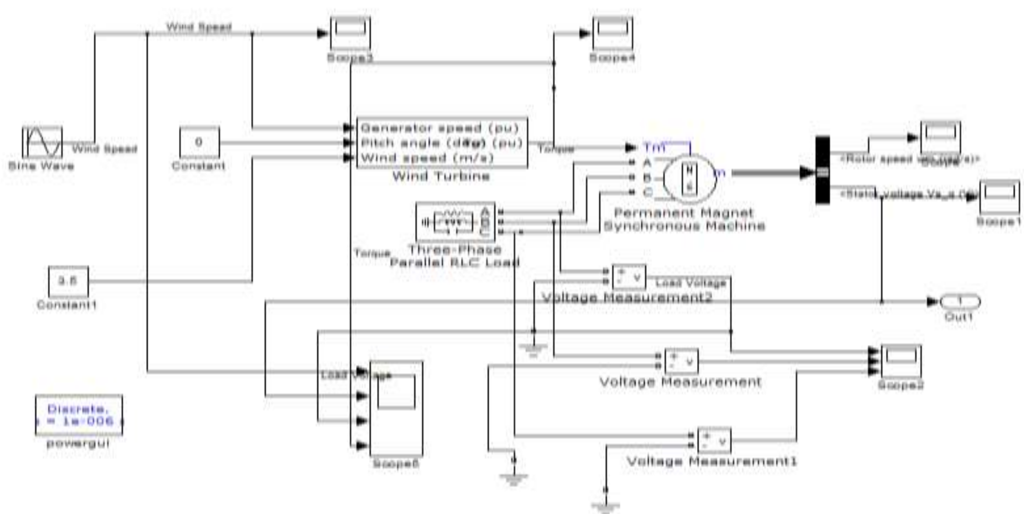

Fig 3 Overall simulation of the 1.5KW (PMSG).

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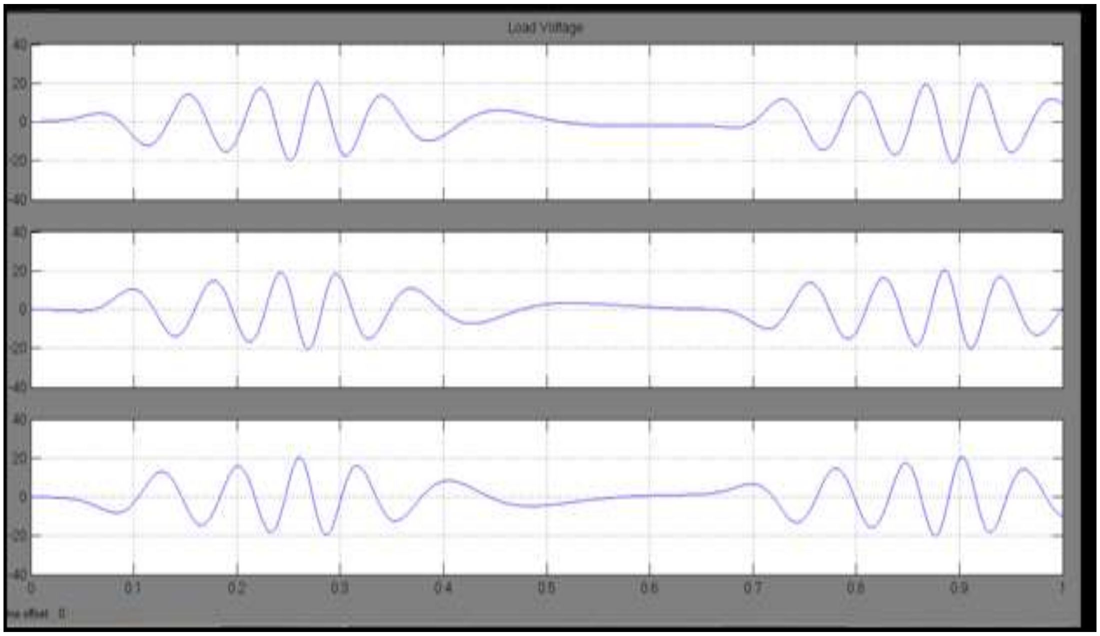

Fig 4 Load Voltages of the (PMSG) wind turbine.

TABLE 1. SIMULATION PARAMETERS

Name	Rating	Unit
Stator phase resistance R_S	2.875	ohms
Inductance L_d, L_q	10.5e-3, 8.5e-3	Henry
Flux linkage by magnets	0.175	weber
Torque	1.05	NM
Inertia	0.0008	J(Kgm^2)
Frictional factor	0.001	F(NMS)
Pole pairs	4	Poles
Nominal power	1.5	KW

AVERAGE WIND DATA

The wind data measured by anemometer installed for the 1.5KW wind turbine at the site in Universiti Putra Malaysia (UPM) was measured for the months of September 2011, October 2011, November 2011 and January 2012 respectively. Table 2. Depict the corresponding average values for the months. The graph for each month is plotted in order to know the maximum and minimum values for the wind speed in order to rotate the blades for proper generation of the wind turbine. Figure 5 to 8 shows the respective graph for each month. From the graph obtained, the minimum cut in speed of 3m/s for the wind velocity to rotate the blades was only attained in two places that mean the wind turbine power output is distorted to zero position due to the fluctuations of the wind velocity within the system operation see fig.4.

TABLE 2. AVERAGE WIND DATA

September 2011	October 2011	November 2011	January 2012
0.99913	1.270485258	1.161814875	1.58240797

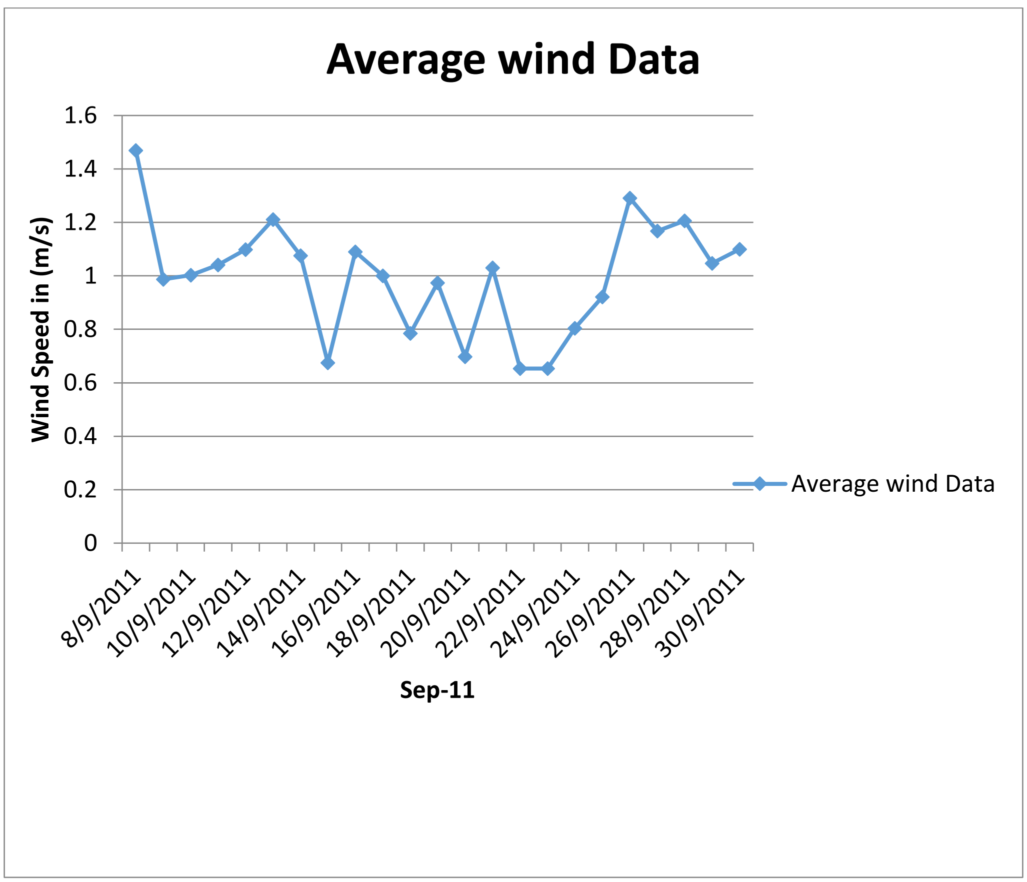

Fig 5. Average Wind Curve for the month of September 2011.

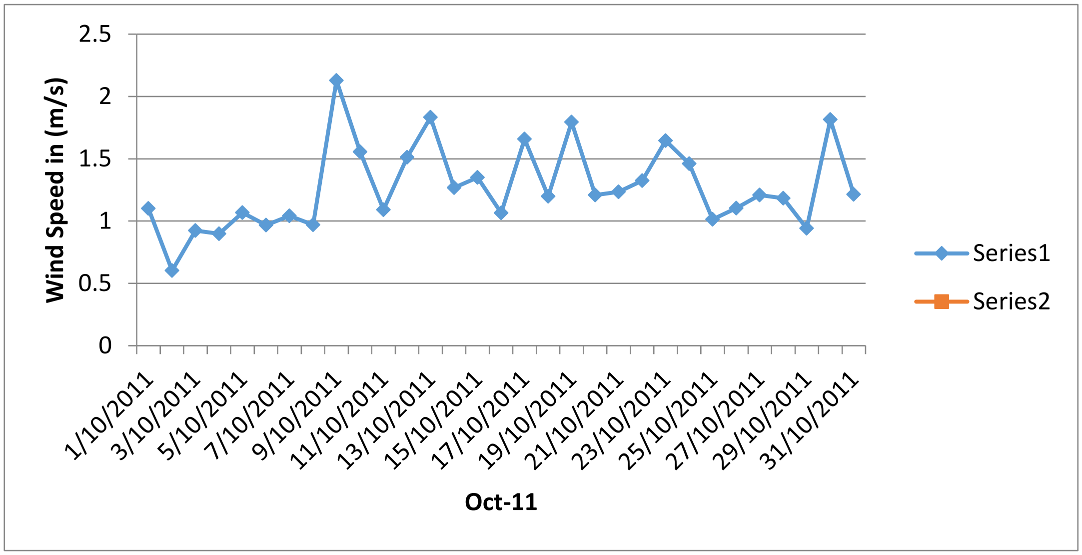

Fig 6 Average Wind curve for the month of October 2011

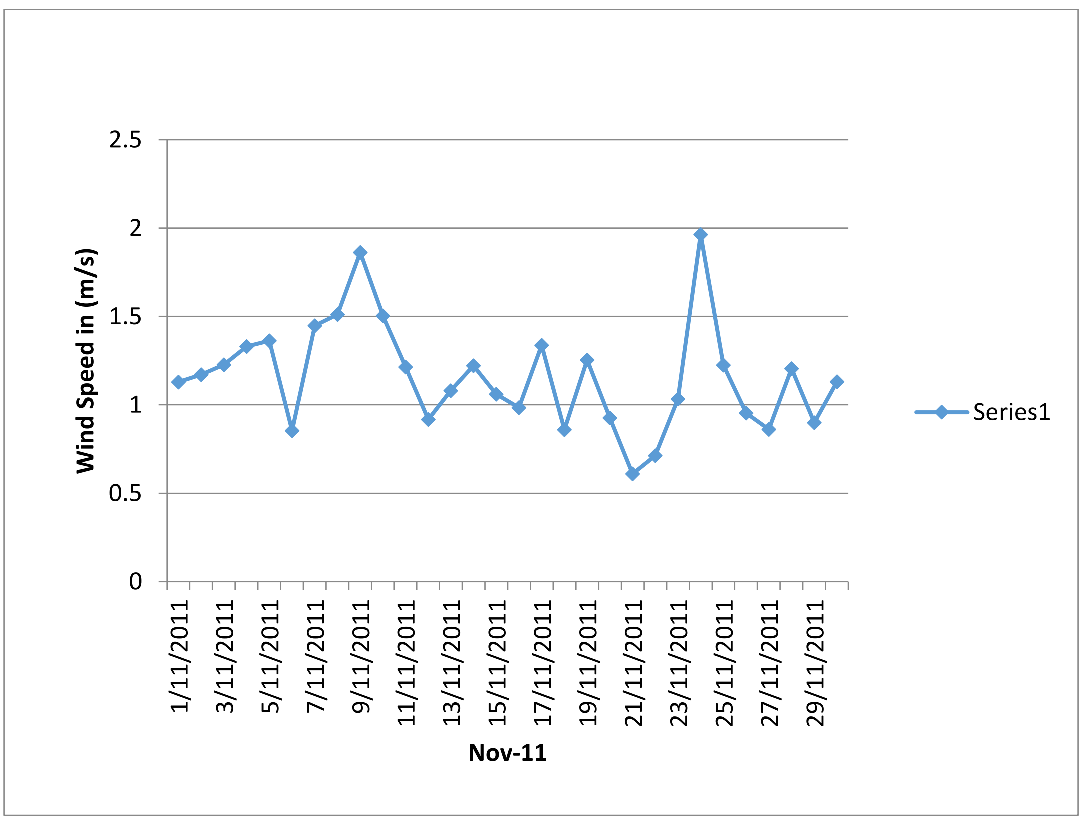

Fig 7. Average wind Curve for the month of November 2011

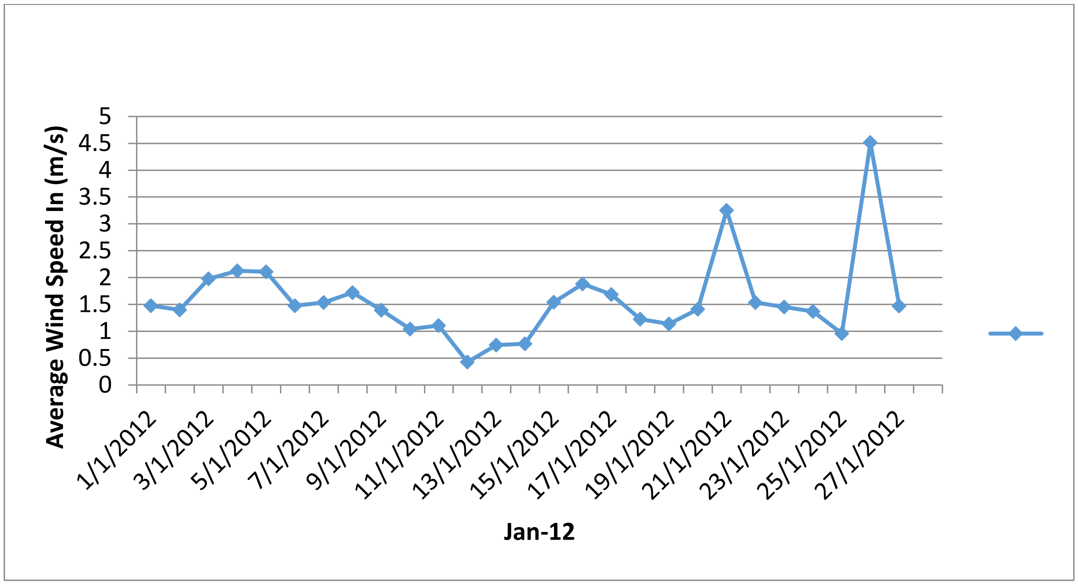

Fig 8. Average Wind Curve for the month of January 2012

POWER QUALITY ISSUES IN WIND TURBINE POWER GENERATION

Power quality issues are one of the factors militating a constant out Voltage/Current in the generation of wind power supply. The problems of these power quality associated with this wind generation are, Voltage unbalance, flicker, harmonic, inter harmonic, as a result of poor availability of the wind velocity within the vicinity of the wind blades. However, there are other factors that caused Voltage fluctuations like, tower shadow effect, wind turbulence, wind vertical gradient and many more [6].

CONCLUSION.

In this paper, the effects and causes of instability of the output Voltage/Current produced by wind turbine is studied, as well as the factors militating the wind blades to have a sufficient wind velocity in order to turn the blades was also studied. Therefore, a geographical survey and necessary measurement should be examined before locating a suitable site for the installation of the wind turbine in order to have a good output Voltage/ Current by the wind turbine.

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