JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Finding The Maximum Power For Wind Generators - Permanental Magnetic Synchronics By P&O Methods

Triet Pham-Minh, Vu Nguyen-Hoang

Abstract - Vietnam has a long coastline favorable for wind power development, and along with technology development, the price is increasingly suitable for wind power development in Vietnam. In this paper, we propose a solution to find the maximum power point for wind generators by the P&O algorithm and establish a system of dynamic equations. The simulation model for the design of dynamic equations is built by Simulink simulation software. Parameters in the controller is selected by logic, statistics, or trial and error to obtain the desired output characteristics when the input parameters are changed randomly within the range Vi allows to find the maximum power transmitter and evaluate the system response when input parameters change.

Keywords: Maximum power, Wind power, Permanent magnet synchronous machine, P&O methods.

Author information: School of Engineering and Technology, Tra Vinh University.
Email: minhtriet@tvu.edu.vn, nghvu@tvu.edu.vn.

I. INTRODUCTION

Wind energy is one of the important renewable energy sources today. Due to its clean and inexhaustible nature, wind energy has recently become the focus of commercial research and development. Currently, wind energy contributes significantly to the world's electricity supply. Although electricity can be supplied through the central grid, there are still remote areas where the grid cannot reach. These places are facing power shortages. A promising sustainable solution is the use of stand-alone wind conversion systems or stand-alone wind turbines connected to local loads. Wind energy is a renewable energy source, so it causes less environmental pollution, and $CO2$ emissions are drastically reduced; Wind energy is inexhaustible and abundant and will not be exhausted like fossil energy sources. In particular, Vietnam is located in the tropical monsoon region, so the energy source is more and more abundant. According to the survey results of the Energy Assessment Program for Asia, Vietnam has the largest wind potential with a total wind power potential estimated at 513,360 MW, 200 times larger than the capacity of Son La Hydropower Plant and more than 10 times the total forecasted capacity of Vietnam's electricity industry in 2020 [1].

II. STUDY OVERVIEW

For Vietnam, due to technology dependence, most equipment and technology are imported, so the cost of wind energy is relatively high. For example, for the Bac Lieu wind power plant: “The price of wind power of Bac Lieu Wind Power Plant proposed to be sold to Electricity of Vietnam (EVN) is up to 12 UScents/kWh. If approved, this cost will be added to the general electricity price and will be borne by the consumer through the monthly electricity payment. An increase in electricity prices will reduce purchasing power" [2]. Expenses to invest in a wind power plant, including the cost of the generator and the wind vanes account for the majority. There are many manufacturers of these devices but with very different prices and technical qualities. Cost for voltage stabilizer and network connection, automatically bringing the current to voltage and frequency with the national electricity network. Costs for batteries, chargers, and equipment to convert electricity from the battery back to AC. These parts are only needed for standalone stations. The cost of the tower or pier depends on the height of the pier, the weight of the equipment, and the geological conditions of the building. The tower part can be manufactured in Vietnam to reduce costs. With wind power stations located on high roofs, this cost is almost negligible. Cost of transportation to the construction site and installation of the station. This cost in Vietnam is much cheaper than in other countries, especially if built in coastal areas, along rivers, or along railway lines. But cost and technology are not the biggest barriers, because looking to the future, Vietnam is having strong technological development; We are in turn mastering technology in many different fields, wind power continues to be supported and invested in Vietnam in the current period and promises to explode in the future. Through the above analysis, we can see the advantages and disadvantages of renewable energy, which the advantages are somewhat outstanding for wind energy to be supported in Vietnam. In Vietnam, large-scale exploitation of natural resources has taken place since the middle of the 19th century - the first half of the 20th century. The Law on Environmental Protection, promulgated by the National Assembly in 1993, 2005, 2014, and Decree 102/2003/ND-CP of the Government in 2003 have clearly indicated that the State's policy is to prioritize the exploitation of renewable energy sources and no negative impact on the environment [3].

III. MAXIMUM POWER IN WIND POWER SYSTEM

A. Direct drive model

The wind speed varies continuously but most of the time the rotation speed of the wind vane is slower than the required rotation of the generator rotor, which in turn requires the use of a gearbox to accelerate. The type of gearbox commonly used in wind generators usually has the structure shown in Figure 1. In addition to keeping the rotor speed stable in accordance with the frequency of the current generated, the use of a gearbox also offers advantages such as reducing by reducing the size of the wind turbine and the blade length significantly, it is possible to install a 3 MW generator in a location where the theoretical wind speed is only adequate for a 1.5 MW generator [4].

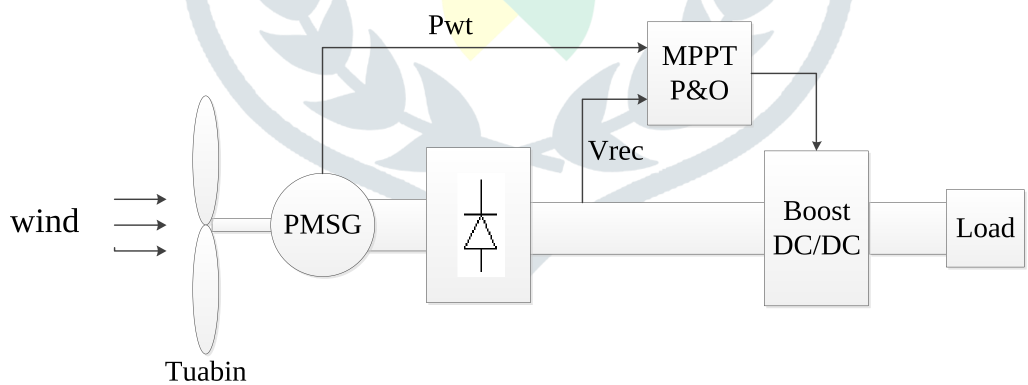

Figure 1. Illustrate the block diagram of the direct drive method.

B. Permanent magnet excitation synchronous generator

The permanent magnet excitation synchronous generator system has a block diagram illustrated in Figure 2. The PMG system is usually used for small and medium power generation; When operating, the system does not need excitation and does not need a brush for the slip ring, so it is easy to control and is popular. PMG can be used with a gearbox or direct drive. PMG is divided into 3 categories such as circular flux (Radial flux PMG), longitudinal flux (Axial flux PMG), and variable flux (Switching flux PMG) [5]. This model does not need to cost excitation, but the permanent flux material is still expensive, so the investment cost is high.

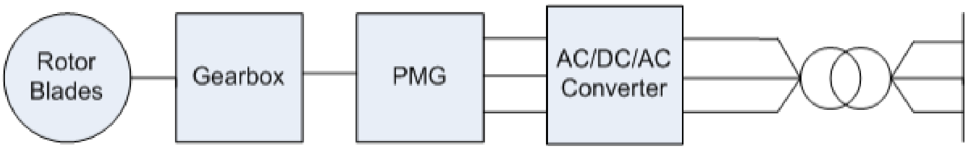

Figure 2. Wind turbine using permanent field generator.

C. Peak power point

The expression for calculating turbine power is rewritten,

$$P_m = \frac{1}{2} C_p \rho \pi R^2 v^3 \qquad (1)$$

Relativity (pu - per unit)

$$P_{m-pu} = K_p C_{pu} v_{pu}^3 \qquad (2)$$

where Pm_pu is the turbine power (relative system - pu) for each value of and R.

is the coefficient (pu) of the maximum Cp value.

vpu is wind speed (in pu units)

kp: power gain when = 1 (pu – 1 unit) and vpu = 1 (pu), then kp 1

The equation describes Cp(λ,β):

$$C_p(\lambda, \beta) = c_1 \left(\frac{c_2}{\lambda_i} - c_3 \beta - c_4 \right) e^{\frac{c_5}{\lambda_i}} + c_6 \lambda_i \qquad (3)$$

with, $\frac{1}{\lambda_i} = \frac{1}{\lambda + 0.08\beta} - \frac{0.035}{\beta^3 + 1}$

The coefficients have the following values: c1 = 0.5176, c2 = 116, c3 = 0.4, c4 = 5, c5 = 21 and c6 = 0.0068, respectively. The cp curve – for different values of pitch angle, is shown in figure 3.

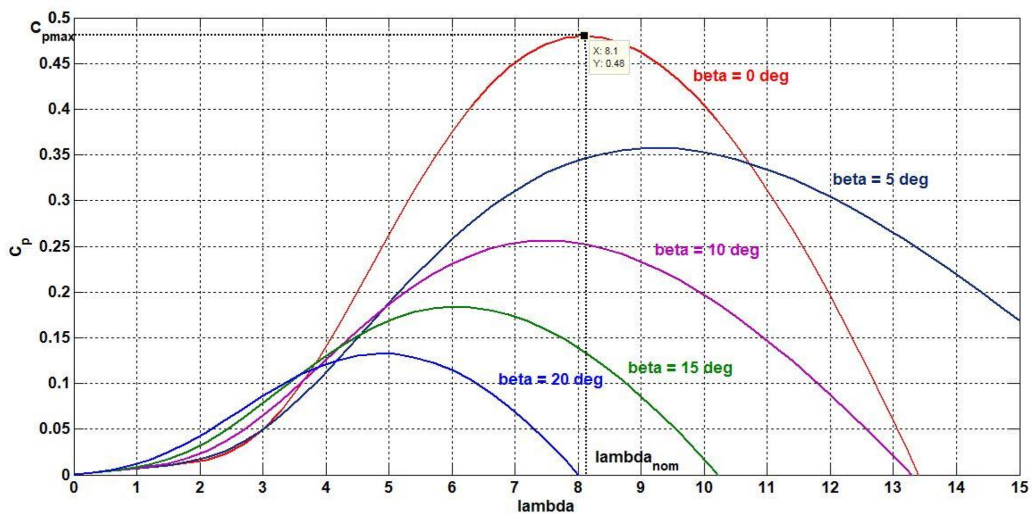

Figure 3. Cp – λ characteristics for different pitch angles β.

Looking at Figure 3, we see that Cp achieved cpmax = 0.48 at = 0 and = 8.1. And this value is called nom.

Turbine power Pm is a function of generator speed, with different wind speeds and at pitch = 0 the turbine power is shown in Figure 4.

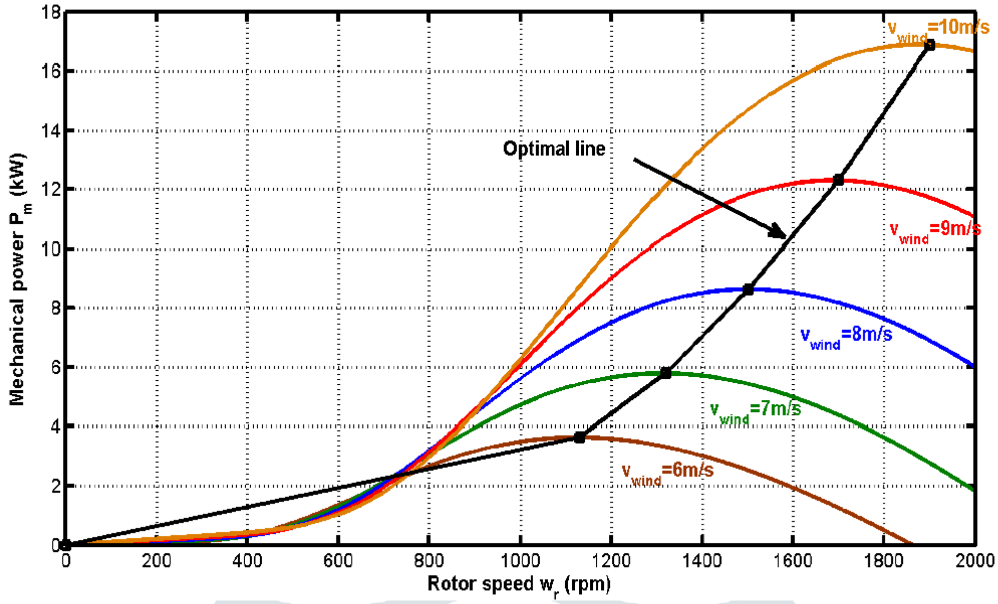

Figure 4. Cp – characteristic at pitch angle = 0

IV - SIMULATION RESULTS

From the proposed block diagram of the system in Figure 1, the permanent magnet wind power generation system is simulated in Simulink/Matlab. The structure and function of the blocks in Figure 1 are generally explained as follows:

The input signal to the P&O MPPT unit consists of two signals ωr and Ppmsg, which is the rotor speed (also the speed of the turbine, because we are using a direct drive system) and the electrical power generated from the synchronous generator. permanent magnets. These two signals are output from the Turbine – generator – rectifier block (Turbine, Generator and Rectifier).

- P&O MPPT block: with input signal "change signal" ωr and signal "power change" Ppmsg; The output signal is the duty cycle value D.

- The D-Pulse block has the main function of converting the D value in analog form to pulse to stimulate the Boost chopper.

- The wind signal is the simulated inlet wind speed which is considered to change randomly, in the article the author only mentions the wind speed within the normal working range of the system. The actual speed selection for the generator must be based on the geo-climate of the survey area. If the wind speed is too low or too high, the control system must be responsible for disconnecting the power electronic system from the main system to ensure safety. Specifically, the speed within the working range of the proposed system is 6-9 m/s.

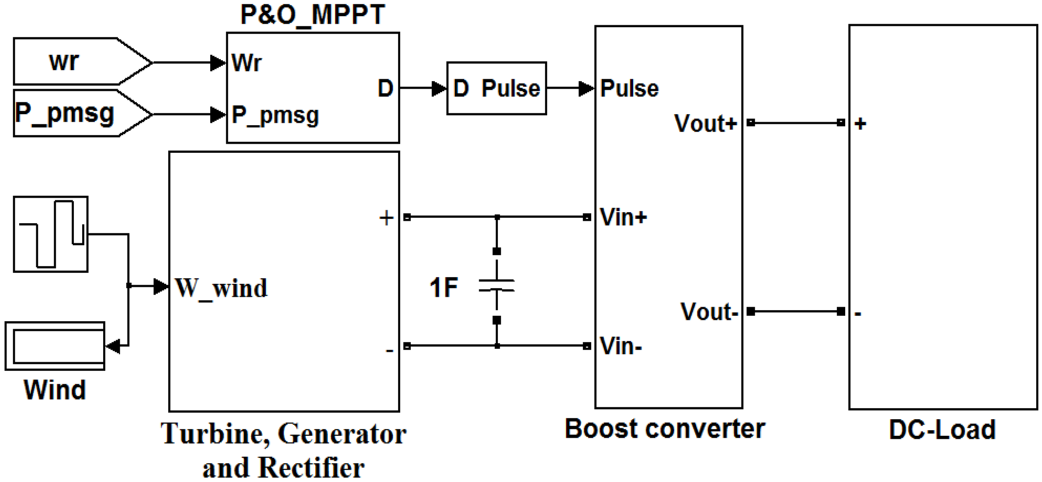

Figure 5: The wind generator system simulation and control circuit in Simulink

- The Turbine, Generator, and Rectifier block is a total block consisting of three small blocks inside the Turbine simulation block, the generator simulation, and the three-phase bridge rectifier. These sub-blocks will be explained in detail in the following sections.
- 1F filter capacitor, selected to reduce DC voltage fluctuations - link to improve the quality of DC voltage applied to the Boost chopper. In the simulation, the author has changed many values of the capacitor in the range of approximately 1F value; the result of the response remains unchanged. However, because of the limited time to do the thesis, trying to find the minimum value that still ensures the system works well is not completed in the thesis, this is one of the shortcomings of the thesis.
- Boost converter block simulates DC/DC chopper boost converter. With the variable D factor, the output voltage value changes when D reaches the appropriate value, and the circuit reaches the impedance matching state, from which the output power from the generator is optimal with the wind speed before.

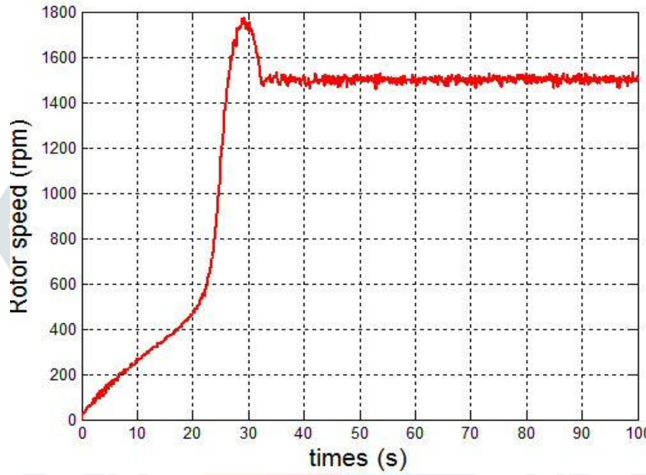

Figure 6: Rotor speed response over time

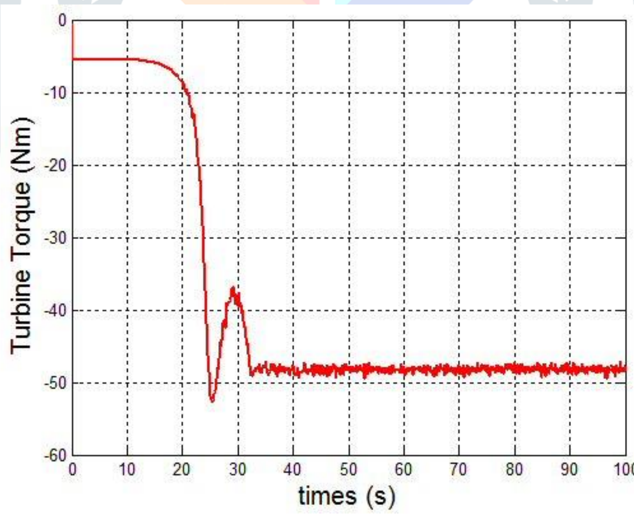

Figure 7: Turbine moment response with time

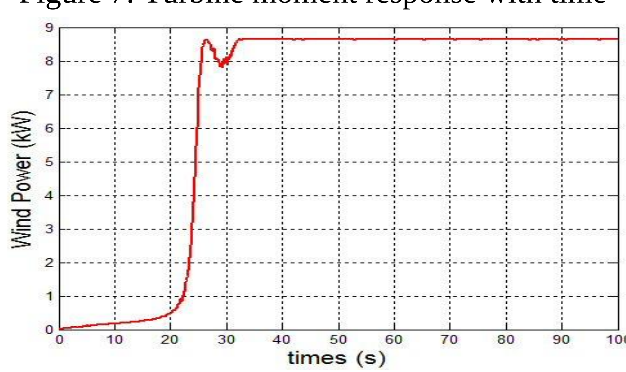

Figure 8: Turbine power response received over time

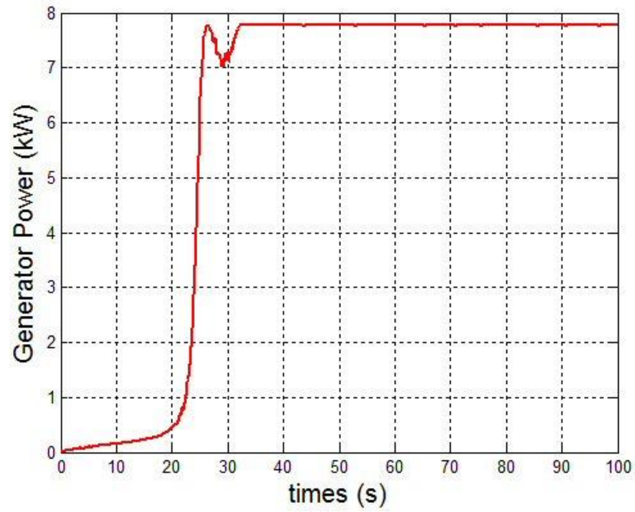

Figure 9: Power response of generator over time

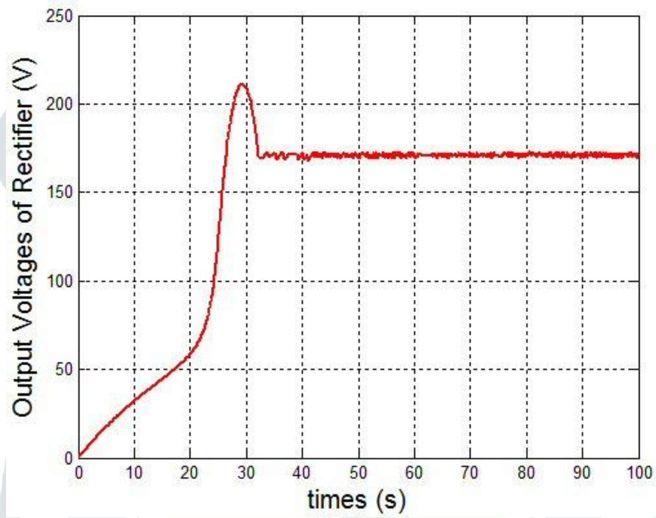

Figure 10: Response of the voltage after the rectifier over time

Figure 6 illustrates the turbine speed response (also the rotor speed) of the generator. Since the wind speed is constant, other environmental conditions (wind turbulence, wind deflection) are also considered to be constant. Therefore, the speed of the turbine does not change. However, due to the large inertia and friction of both turbine and generator systems and previously, the rotor was stationary, the steady-state time was as large as 28 seconds. We think that this is the right time to practice.

Figure 7 shows the response of the turbine torque over time, since this is a generator system, mechanical torque is conventionally considered to be negative relative to electromagnetic power, so the torque is always negative in the figure.

Figures 8 and 9 represent the response of turbine power and generator power, which are equal under ideal conditions (ignoring losses). However, in the thesis, because the friction coefficients of the generator and the turbine are included, the generated generator power is smaller than the turbine's capacity. This loss accounts for about 10%. Since the wind speed is constant, the maximum power the system can generate remains the same regardless of the change in load impedance. This is said to illustrate the correctness of the simulated algorithm.

Figure 10 illustrates the output voltage of the generator after rectification. Since the generator power and generator speed are constant during the steady-state phase, the output voltage is also constant, and independent of the load changes. This result is completely consistent with the logic of the theory stated in this paper. in the thesis.

In summary, Through the simulation state "constant wind speed, variable load" we can completely check the correctness of the built system. The response obtained is in full agreement with the theoretical logic stated in all literature on wind generator systems using permanent magnet synchronous generators.

V. CONCLUSION

In this study, we have built and successfully simulated the algorithm to find the working point with the maximum capacity P&O. Successfully simulated model of the wind energy system: wind turbine, permanent magnet synchronous generator, uncontrollable three-phase bridge rectifier, Boost converter, MPPT P&O algorithm. The author also proposes a method to evaluate and verify the correctness and effectiveness of the system-building model by analyzing the response signal based on the simulation of load changes when the wind speed is constant, at the same time a quantitative evaluator of the model's input-output response.

REFERENCES

[1] Charles F. Brush. A Wind Energy Pioneer [online], [http://xn--drmstrre-64ad.dk/wp-content/wind/miller/windpower%20web/en /pictures/brush.htm >], (accessed date: 20 October 2022).

[2] Tran Thanh Lam & Nguyen Linh Chi (2015). Analysis of costs - benefits of exploiting wind power in Bac Lieu area [online], viewed January 12, 2022.

[3] Ho Pham Huy Anh, Nguyen Huu Phuc, Nguyen Van Tai, Pham Dinh Truc, Nguyen Quang Nam, Tran Cong Binh & Phan Quang An (2013). Engineering of renewable energy systems, Ho Chi Minh City University of Technology.

[4] Henk Polinder, Frank F. A. van der Pijl, Gert-Jan de Vilder & Peter J. Tavner (2006). Comparison of Direct-Drive and Geared Generator Concepts for Wind Turbines, IEEE transactions on energy conversion. Vol. 21 no. 3, September 2006.

[5] H. Li & Z. Chen (2007). Overview of different wind generator systems and their comparisons, Published in IET Renewable Power Generation. Received on 24th January 2007, Revised on 23rd August 2007.doi: 10.1049/iet-rpg: 20070044