



Digital Receipt

This receipt acknowledges that **Turnitin** received your paper. Below you will find the receipt information regarding your submission.

The first page of your submissions is displayed below.

Submission author: Bernadeta Wuri Harini
Assignment title: Quick Submit
Submission title: Implementation of Maximum Power Point Tracking Algorith...
File name: m_on_Wind_Turbine_Generator_using_Perturb_and_Observe...
File size: 609.02K
Page count: 7
Word count: 3,572
Character count: 17,765
Submission date: 03-May-2021 01:54PM (UTC+0700)
Submission ID: 1576574709

2017 International Conference on Sustainable Energy Engineering and Application (ICSEEA)

Implementation of Maximum Power Point Tracking Algorithm on Wind Turbine Generator using Perturb and Observe Method

Indra Nurzaman¹, Bernadeta Wuri Harini¹, Nanda Avianto¹, Feri Yusivar^{1,*}

¹Electrical Engineering, Universitas Indonesia
Kampus UI Depok 16424, West Java, Indonesia
*yusivar@yahoo.com

Abstract—Energy from wind movement can be one of the alternatives of the renewable power sources in fulfilling the need of electrical energy. This can be achieved by converting wind movement energy into electrical energy. The wind turbine is a device to convert energy from wind movement into electrical energy. The challenge in the usage of wind turbine generator is that the wind velocity is not always constant, hence the power generated by wind turbine generator is not always at its maximum point. That is why it is required a control so that the power generated by the wind turbine is always maximum. The control is conducted by applying the maximum power point tracking (MPPT) algorithm to the dc-dc boost converter so that the output power from the wind turbine generator can be controlled and always having a maximum value.

Keywords—Wind turbine generator; Boost converter; MPPT algorithm

I. INTRODUCTION

The need for renewable energy sources is growing rapidly. Various factors are identified as the main causes, such as limited availability of fossil natural resources and the increasing of public awareness of the negative effects of using fossil fuel on the environment. Therefore an alternative energy source is needed to reduce the use of fossil fuels [1-6]. Indonesia is one of the countries that has a big potential of natural resources. One of the resources that can be utilized and also has good potential to meet the energy needs is wind energy. However, the utilization of wind energy as one of the alternative sources of electrical energy today has not been well exploited due to various factors such as wind speed that is not constant in various places and has small efficiency in terms of energy conversion.

As an energy converter tool, wind turbine combined with a generator is required to convert wind energy into electric energy. The wind speed is not always constant, it can vary depending on the weather and conditions, and therefore the power generated is fluctuating. In this condition, a technique that can maximize the work of wind turbine required to make the output power always at a maximum value [7].

One of the common techniques is to implement the maximum power point tracking (MPPT) algorithm. The MPPT algorithm is the algorithm used to obtain maximum power

under each condition. Implementation of MPPT algorithm used a dc-dc converter and microcontroller as its main controller. In this study, the author used a dc-dc boost converter to run the maximum power point tracking algorithm (MPPT) to control the output power of wind turbine generator.

II. MPPT WIND TURBINE SYSTEM MODELING

A. Wind Turbine

A wind turbine is a tool used to convert kinetic energy due to wind movement into electrical energy. The energy of the wind movement is converted into mechanical rotation by the turbine blades and rotor, rotating the shaft connected to a PMSG generator. As a result, the electrical energy is generated from the generator's rotation [1,8]. The maximum power that can be converted from wind movement by a wind turbine can be formulated as [8]:

$$P_{max} = \frac{1}{2} \rho A v_t^3 C_p \quad (1)$$

P_{max} is the maximum power value (watt) that can be generated from wind movement, ρ is the air density (kg/m^3), v_t is wind velocity (m/s) and C_p is the power coefficient value (C_p).

The value of C_p determines how much power is generated by wind movement. The power coefficient value (C_p) can be formulated with the function with the value of tip speed ratio (λ) and the angle of the blade (δ), as the following:

$$C_p(\lambda, \delta) = C_1 \left(C_2 \frac{1}{\lambda} - C_3 \delta - C_4 \delta^2 - C_5 \right) e^{-C_6 \delta} \quad (2)$$

The values of $C_1 - C_6$ and λ depend on the type of rotor and the characteristics of the wind turbine. The parameter values of β and tip speed ratio (λ) are determined as follows:

$$\frac{1}{\beta} = \frac{1}{\lambda + 0.005} - \frac{0.005}{\lambda^3} \quad (3)$$

$$\lambda = \frac{v_{ref}}{v_{actual}} \quad (4)$$

Implementation of Maximum Power Point Tracking Algorithm on Wind Turbine Generator using Perturb and Observe Method

by Harini Bernadeta Wuri

Submission date: 03-May-2021 01:54PM (UTC+0700)

Submission ID: 1576574709

File name: m_on_Wind_Turbine_Generator_using_Perturb_and_Observe_Method.pdf (609.02K)

Word count: 3572

Character count: 17765

Implementation of Maximum Power Point Tracking Algorithm on Wind Turbine Generator using Perturb and Observe Method

Indra Nurzaman¹, Bernade Wuri Harini¹, Nanda Avianto¹, Feri Yusivar^{1,*}

¹Electrical Engineering, Universitas Indonesia
Kampus UI Depok 16424, West Java, Indonesia

*yusivar@yahoo.com

Abstract—Energy from wind movement can be one of the alternatives of the renewable power source in fulfilling the need of electrical energy. This can be achieved by converting wind movement energy into electrical energy. The wind turbine is a device to convert energy from wind movement into electrical energy. The challenge in the usage of wind turbine generator is that the wind velocity is not always constant, hence the power generated by wind turbine generator is not always at its maximum point. That is why it is required a control so that the power generated by the wind turbine is always maximum. The control is conducted by applying the maximum power point tracking (MPPT) algorithm to the dc-dc boost converter so that the output power from the wind turbine generator can be controlled and always having a maximum value.

Keywords—Wind turbine generator; Boost converter; MPPT algorithm

I. INTRODUCTION

The need for renewable energy sources is growing rapidly. Various factors are identified as the main causes, such as limited availability of fossil natural resources and the increasing of public awareness of the negative effects of using fossil fuel on the environment. Therefore an alternative energy source is needed to reduce the use of fossil fuels [1-6]. Indonesia is one of the countries that has a big potential of natural resources. One of the resources that can be utilized and also has good potential to meet the energy needs is wind energy. However, the utilization of wind energy as one of the alternative sources of electrical energy today has not been well exploited due to various factors such as wind speed that is not constant in various places and has small efficiency in terms of energy conversion.

As an energy converter tool, wind turbine combined with a generator is required to convert wind energy into electric energy. The wind speed is not always constant, it can vary depending on the weather and conditions, and therefore the power generated is fluctuating. In this condition, a technique that can maximize the work of wind turbine required to make the output power always at a maximum value [7].

One of the common techniques is to implement the maximum power point tracking (MPPT) algorithm. The MPPT algorithm is the algorithm used to obtain maximum power

under each condition. Implementation of MPPT algorithm used a dc-dc converter and microcontroller as its main controller. In study, the author used a dc-dc boost converter to run the maximum power point tracking algorithm (MPPT) to control the output power of wind turbine generator.

II. MPPT WIND TURBINE SYSTEM MODELING

A. Wind Turbine

A wind turbine is a tool used to convert kinetic energy due to wind movement into electrical energy. The energy of the wind movement is converted into mechanical rotation by the turbine blades and rotor, rotating the shaft connected to a PMSG generator. As a result, the electrical energy is generated from the generator's rotation [1,8]. The maximum power that can be converted from wind movement by a wind turbine can be formulated as [8] :

$$P_{\max} = \frac{1}{2} \rho A v_1^3 C_p \quad (1)$$

P_{\max} is the maximum power value (watt) that can be generated from wind movement, ρ is the air density (kg/m^3), v_1 is wind velocity (m/s) and C_p is the power coefficient value (C_p).

The value of C_p determines how much power is generated by wind movement. The power coefficient value (C_p) can be formulated with the function with the value of tip speed ratio (λ) and the angle of the blade (δ), as the following:

$$C_p(\lambda, \delta) = C_1 \left(C_2 \frac{1}{\beta} - C_3 \delta - C_4 \delta^x - C_5 \right) e^{-C_6 \frac{1}{\beta}} \quad (2)$$

The values of $C_1 - C_6$ and x depend on the type of rotor and the characteristics of the wind turbine. The parameter values of β and tip speed ratio (λ) are determined as follows:

$$\frac{1}{\beta} = \frac{1}{\lambda + 0.089} - \frac{0.035}{1 + \delta^3} \quad (3)$$

$$\lambda = \frac{\omega_m R}{v_{wind}} \quad (4)$$

where ω_m is the rotation speed of the turbine rotor and R is the radius of the turbine blades and v_{wind} is the wind speed.

B. Wind Turbine Shaft System

Shaft system modeling in wind turbines as shown in the Fig.1. Shaft system in a wind turbine can be modeled as follows:

$$\frac{d\omega_G}{dt} = \frac{T_e - \frac{T_t}{K} - B\omega_G}{J_t K^2 + J_p} \quad (5)$$

$$\frac{d\omega_t}{dt} = \frac{T_e - \frac{T_t}{K} - B\omega_G}{K} \quad (6)$$

$$\frac{d\theta_G}{dt} = \omega_G \quad (7)$$

$$\frac{d\theta_t}{dt} = \omega_t \quad (8)$$

ω_g (rad/s) is the speed of the axis generator, ω_t (rad/s) is the speed of the turbine shaft, θ_g (°) is the angle position of the generator shaft, θ_t (°) is the angle position of the turbine shaft, T_e (N-m) is the torsion of the generator PMSG, T_t (N-m) is the torsion of the turbine, K is gear ratio, B (Nms/rad) is damping coefficient, J_t (kg-m²) is inertia of the turbine, J_p (kg-m²) is inertia of PMSG.

C. Permanent Magnet Synchronous Generator

Permanent magnet synchronous generator (PMSG) is an

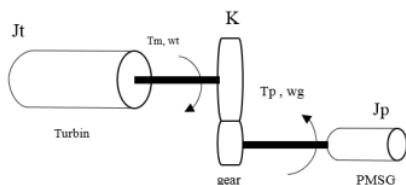


Fig. 1. Wind Turbine Shaft System

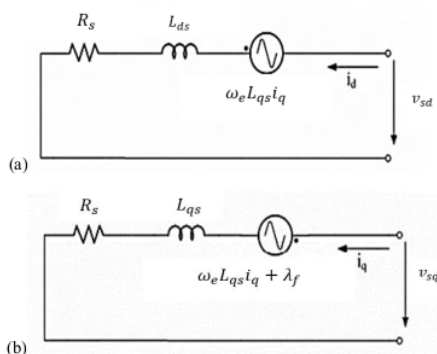


Fig. 2. (a) PMSG equivalent circuit in axis d and (b) PMSG equivalent circuit in axis q.

AC machine that converts mechanical rotation energy into electrical energy. In modeling PMSG, a model is used in the d-q axis. Fig. 2 shows an equivalent PMSG circuit in the d-q axis.

The equations for PMSG can be arranged as follows:

$$\lambda_{sq} = L_{sq} i_{sq} \quad (9)$$

$$\lambda_{sd} = L_{sd} i_{sd} + \lambda_f \quad (10)$$

$$v_{sq} = R_s i_{sq} + \omega_e (L_{sd} i_{sd} + \lambda_f) + \frac{dL_{sq} i_{sq}}{dt} \quad (11)$$

$$v_{sd} = R_s i_{sd} - \omega_e (L_{sd} i_{sq}) + \frac{d(L_{sd} i_{sd} + \lambda_f)}{dt} \quad (12)$$

Assuming the flux on the rotor in the dx axis is represented in a constant current source which can be described as $\lambda_f = L_m i_f$. The stator current equation can be determined as follows:

$$\frac{d}{dt} \begin{bmatrix} i_{sd} \\ i_{sq} \end{bmatrix} = - \begin{bmatrix} \frac{R_s}{L_{sd}} & -\frac{L_{sq}}{L_{sd}} \omega_e \\ \frac{L_{sd}}{L_{sq}} \omega_e & \frac{R_s}{L_{sq}} \end{bmatrix} \begin{bmatrix} i_{sd} \\ i_{sq} \end{bmatrix} + \begin{bmatrix} \frac{1}{L_{sd}} & 0 \\ 0 & \frac{1}{L_{sq}} \end{bmatrix} \begin{bmatrix} v_{sd} \\ v_{sq} \end{bmatrix} \quad (13)$$

The electric angular velocity (rad/s) of the generator is $\omega_e = z_p \omega_m$. Therefore, electrical torque equation (Te) PMSG is determined as follows :

$$T_e = \frac{3}{2} z_p (\lambda_m i_{sq} + i_{sd} i_{sq} (L_{sd} - L_{sq})) \quad (14)$$

where v_{sq} is stator voltage axis q, v_{sd} is stator voltage axis d, R_s is resistance per phase (Ohm), ω_e is electrical speed (rad/s), λ_q flux stator axis q (Wb), λ_{ds} is flux stator axis d (Wb), L_{sq} is q axis stator inductance (H), L_{sd} is d axis stator inductance (H), λ_f is flux rotor permanent magnet (Wb), L_m is permanent magnet inductance (H), i_f is d-axis rotor current (A), i_{sq} is q-axis rotor current (A), i_{sd} is d-axis stator currents (A), T_e is electric torsion (Nm), λ_m is flux permanent magnet (Wb), and z_p is number of pole pairs

D. Rectifier Boost Converter

Fig. 3 shows a converter boost rectifier model, where 3 phase voltages are connected to rectifier and boost converter.

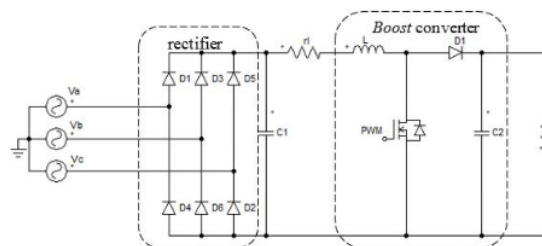


Fig. 3. Rectifier Boost converter.

TABLE I. SWITCHING CONDITIONS OF RECTIFIER BOOST CONVERTER

No	Switch	Va	Vb	Vc
1	ON	1	1	0
2		0	1	0
3		0	1	1
4		0	0	1
5		1	0	1
6		1	0	0
7	OFF	1	1	0
8		0	1	0
9		0	1	1
10		0	0	1
11		1	0	1
12		1	0	0

Rectifier used in this study is a 6 pulse rectifier which has 6 switching conditions on the system. The diode condition is ON when the voltage v_a or v_b or v_c is greater than v_{DC} (C1 voltage). The MOSFET has two conditions, ON and OFF. Consequently, the rectifier boost converter will have 12 different switching conditions. Table I shows a condition of switching rectifier boost converter.

E. Low Pass Filter

Low pass filter is a filter that will weaken signals that have a frequency higher than cut-off frequency. This study used first order low pass filter. The function of the first order low pass filter is as follows:

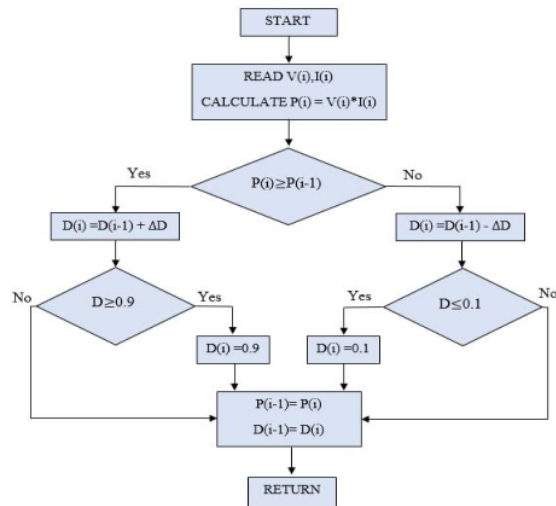


Fig. 4. Flow diagram of P&O algorithm.

$$\frac{V_o}{V_i} = \frac{1}{\tau s + 1} \quad (15)$$

V_o is the output voltage, V_i is the input voltage and τ is the cut-off frequency of the filter.

F. MPPT Algorithm

One of the commonly used MPPT algorithms is P&O (perturb and observe). Flow diagram of the P&O algorithm is shown in Fig. 4.

In the MPPT P&O algorithm, the voltage (V) and current (I) output of the rectifier are read and the power value P(i) at that time is calculated. The power value P(i) is then compared with the power value in the previous calculation P(i-1). If the power P(i) is greater than the previous power P(i-1), then the duty cycle (D) value will be increased by ΔD . Conversely, if the power P(i) is less than the previous power P(i-1), then the duty cycle (D) value will be decreased by ΔD . If the duty cycle value of D(i) that has been obtained is greater or equal to 0.9, then the duty cycle D(i) will be set to 0.9. If the duty cycle value of D(i) that has been obtained is smaller or equal to 0.1, then the duty cycle D(i) will be set to 0.1. This is done to limit the resulting duty cycle value to remain in the range of values of 0.1 to 0.9. The power value P(i) is then stored in the memory and becomes the power value of P(i-1) at the next calculation. Likewise, the value of duty cycle D(i) will be stored also in the memory and becomes the duty cycle D(i-1) in the next calculation.

III. MPPT WIND TURBINE DESIGN SYSTEM

Fig. 5 shows the schematic of MPPT wind turbine system as a whole. The voltage and current of the 42-re-phase AC wind turbine generator are rectified to the DC voltage and current by the rectifier. The output of the rectifier block (V_{dc} and I_{dc}) will be the input of the MPPT controller block. The MPPT controller block will calculate the duty cycle value based on the MPPT algorithm that built and will produce the duty cycle value corresponding to the maximum power of the wind turbine at that time. The duty cycle value is then used by the converter boost to determine how large the step-up input voltage (V_{dc}) is required to produce the maximum power.

In the wind turbine MPPT system design, modeling and simulation of the mathematical equation of each subsystem within CMEX on MATLAB/Simulink have been done. System modeling includes wind turbine modeling, shafts, PMSG, converter boost converters, and MPPT algorithms. Fig. 6 shows the whole model simulation performed on MATLAB/Simulink.

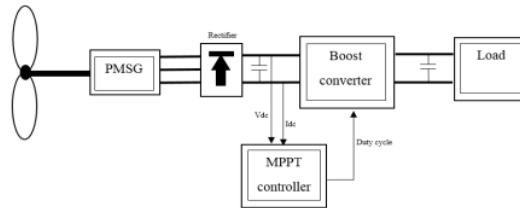


Fig. 5. Schematic of MPPT wind turbine system.

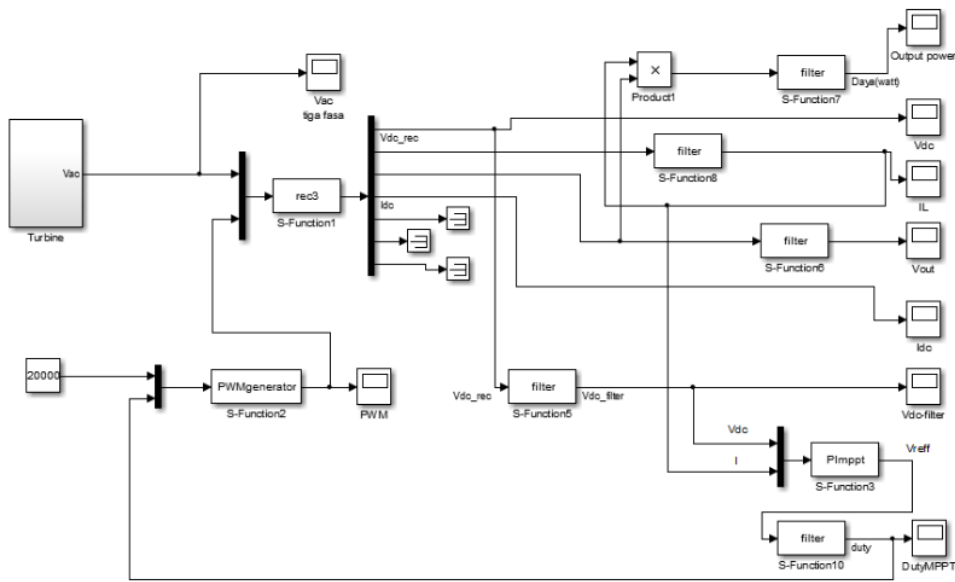


Fig. 6. The whole MPPT wind turbine system on MATLAB/Simulink.



Fig. 7. Wind turbine MPPT in real system.

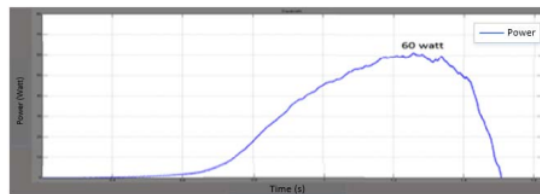


Fig. 8. Characteristics of the wind turbine generator output power at 2 m/s.

TABLE II. OUTPUT POWER CHARACTERISTICS OF WIND TURBINES ON VARIOUS THE WIND SPEED

No	Wind speed (m/s)	Max Power (Watt)
1	2	60
2	2.5	80
3	3	120
4	4.5	230

After modeling and simulation, then the author designed a wind turbine MPPT in the real system. The design of MPPT wind turbine in the real system includes wind turbine system design, converter boost converter system and wind tunnel manufacture. Fig. 7 shows the whole MPPT wind turbine system that has been built.

IV. TESTING AND ANALYSIS

A. MPPT algorithm on MATLAB / Simulink Testing

This test is carried out by providing varying wind velocity inputs on the turbine simulation block with values of 2m/s,

2.5m/s, 3m/s and 4.5m/s. The first step is to get a graph of the wind turbine generator power output characteristics at 32 h given wind speed. Then test the MPPT algorithm on the wind turbine generator system. Fig. 8 shows the characteristics of the wind turbine generator output power at 2m/s. The test results of simulation output power characteristics of wind turbines at various wind speed can then be seen in Table II.

The testing of MPPT algorithm to the variation of the wind speed is performed after obtaining the output power characteristic graph. Fig. 9 shows changes in wind speed variation. Power MPPT algorithm calculation results are shown

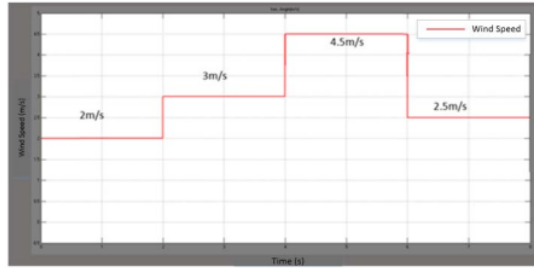


Fig. 9. Changes in wind speed variation graph.

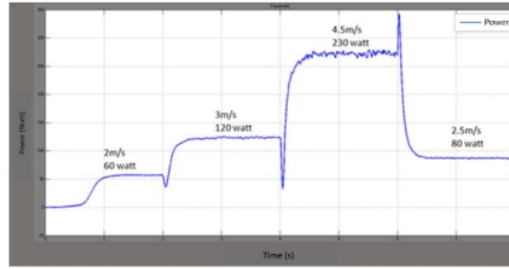


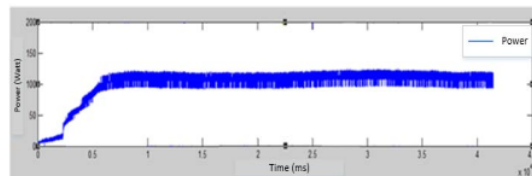
Fig. 10. Power MPPT algorithm calculation results.

in Fig. 10. Based on the test results in Fig. 10, the MPPT algorithm that has been built in the simulation is able to make the wind turbine produces maximum power at any given wind speed variation.

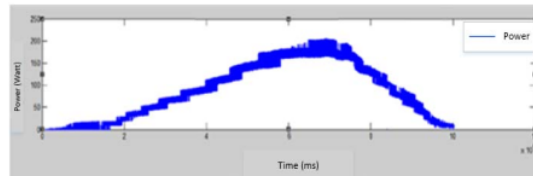
B. Turbine Output Power Characteristics Based on Load Variations Testing

In this test, variations of the load in MPPT system of the wind turbine generator are used. The loads used are 1000 ohm 100 watts resistor, 200 watts 1500 Ohm resistor, 2500 Ohm 300 watts resistor, 1 incandescent lamp, and 2 incandescent lamps. In a load variation, two tests were conducted, first, testing the output power of wind turbine generator without a controller and the second is testing to determine the maximum output power of the wind turbine generator. Testing the output power of an unmanned wind turbine generator is performed to find out how much output power can be generated when no power control is performed by the MPPT algorithm on each load. Whereas the maximum output power of wind turbine generator is performed to find out the maximum power that can be generated by wind turbine generator at each load.

The method used to test the maximum output power of wind turbine generator is the duty cycle set at zero, then the duty cycle value is incremented with the added factor of 10^{-6} . From the increase of duty cycle, the author will be able to examine the response of wind turbine output power at certain load condition. Testing is performed by connecting dc-dc boost converter with a certain variation of load to obtain the response of different power output of each load. The characteristics of wind turbine power with load variation carried out at a constant wind speed of 8.5 m/s. Fig. 11 shows graphic of wind turbine power characteristics to the load variation along with the given duty cycle.



(a)



(b)

Fig. 11. (a) The output power of the generator without the controller at 1000 ohm 100 watt resistor load, (b) Graph of power characteristics at 1000 Ohm 100 Watt resistor load.

C. MPPT algorithm without filter testing

Testing the MPPT algorithm on the system is projected to validate the algorithm that has been built previously. The system used the same load variations and system configuration as characteristic testing. The MPPT algorithm test is performed by connecting the three-phase wind turbine generator output to the converted dc-dc boost converter. The three-phase output will then pass through a three-phase rectifier present in the dc-dc boost converter system. The output voltage and current from the rectifier will then be sampled for later processing the MPPT algorithm. The test is carried out at a constant wind speed of 8.5 m/s. Fig. 12 shows one of the results of the MPPT algorithm without filter (1000 Ohm 100 watts load).

D. MPPT algorithm with filter testing

The MPPT algorithm with low pass filter testing is performed by applying filter algorithm at input voltage (V_{dc}) and input current (I_{dc}). It is to minimize the noise that occurs in both variables and to obtain a better duty cycle calculation on the MPPT algorithm that has been built. The cut-off frequency of the filter used is 100 Hz. The same system configuration as MPPT algorithm with filter testing for each load variation. The test is carried out at a constant wind speed of 8.5 m/s. Fig. 13 shows one of the results of MPPT algorithm with filter testing (1000 Ohm 100 watts load):

E. Test Results of Power Characteristics and MPPT algorithm on Load Variations

Based on the testing of wind turbine generator power output characteristics and MPPT algorithm on load variation, the data obtained are shown in Table III. Table III shows the comparison of the output power without MPPT controller and output power using MPPT algorithm. It can be seen that by implementing the MPPT algorithm on the wind turbine

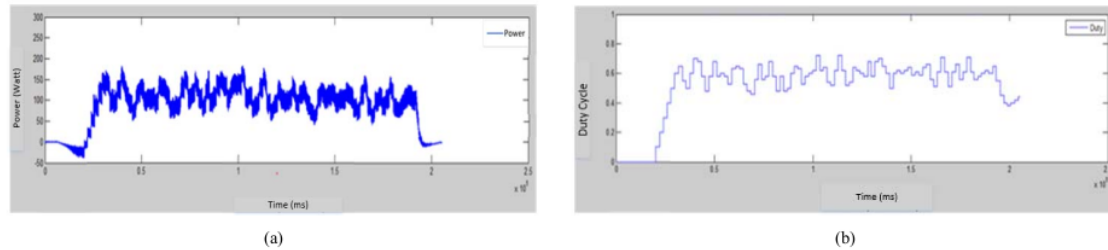


Fig. 12. (a) Power resulted without MPPT filter 1000 Ohm 100 watts load. (b) Duty Cycle.

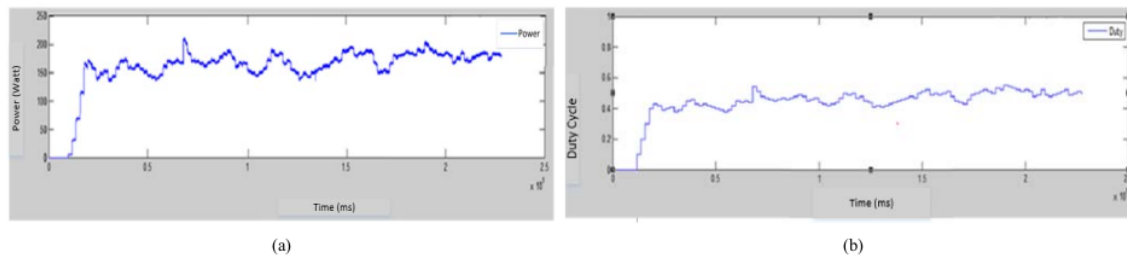


Fig. 13 (a) shows one of the results of MPPT algorithm with filter testing (1000 Ohm 100 watt load). (b) Duty Cycle.

TABLE III. TURBINE GENERATOR OUTPUT POWER ON LOAD VARIATIONS

Load	Power (watt)			
	W/O controller MPPT	Max. Power Obtained	Power MPPT W/O filter	Power MPPT With filter
Resistor 1000 Ohm 100 watt	100	150-160	120	150
Resistor 1500 Ohm 200 watt	100	170-190	150	170
Resistor 2500 Ohm 300 watt	120	250	200	250
1 Incandescent Lamp 60 watt	40	130-150	120	130
2 Incandescent Lamp 120 watt	50	80-100	80	80

generator, the power generated by the wind turbine generator at each load variation became higher. It can also be seen that by applying the filter algorithm, the output power value generated

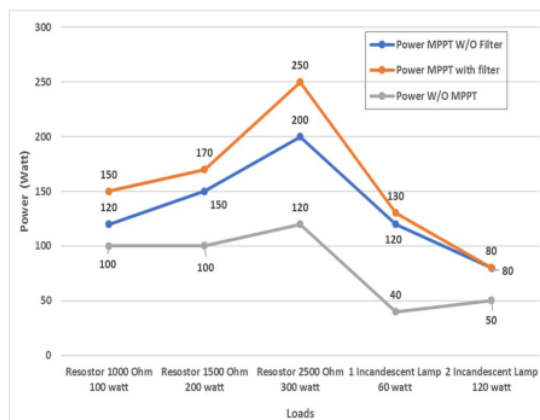


Fig. 14. Graphic of turbine generator output power to load variation.

is higher and closer to its maximum power value. This proves that the filter algorithm can produce a better regulation of MPPT algorithm. Figure 14 shows the outputs power of wind turbine generator to the variation of loads. From Fig. 14, it can be concluded that the power generated by the MPPT algorithm always has higher values than the wind turbine generator without the MPPT controller. The power generated by the MPPT algorithm using filter has higher values than power generated by the unfiltered MPPT algorithm.

F. Characteristic Testing of Wind Turbine Output Power to Wind Speed Variations

This test is performed by adjusting the wind speed with certain variations; 8.5 m/s, 6m/s, and 4.5 m/s. Wind speed was measured by using an anemometer to obtain proper wind speed. The same method on testing turbine characteristic to load variation was performed, duty cycle value incremented with addition factor 10^{-6} . The data resulted in this testing as shown in Table IV. Fig. 15 shows the output based on the test result in Fig. 14.

TABLE IV. CHARACTERISTICS OF WIND TURBINE POWER TO WIND SPEED VARIATIONS

No	Wind Speed (m/s)	Max. Power (Watt)
1	4.5	30
2	6	90
3	8.5	190

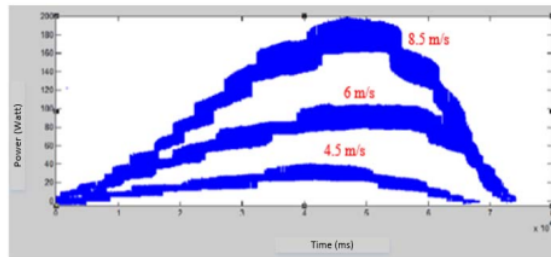


Fig. 15 Power characteristics to wind speed variations.

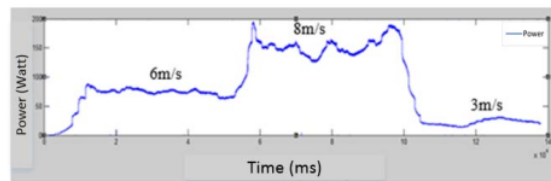


Fig. 16. The output power of MPPT algorithm to variations of wind speed.

G. MPPT algorithm Testing to Wind Speed Variation

This test is performed to determine the dynamic response of the MPPT algorithm that has been built by applying a low pass filter algorithm to the system. The load used on the system is a 100 watts 1000 Ohm resistor and the variations of wind speed were given on the system. First wind speed was set at 6 m/s, raised to 8 m/s then lowered to 3 m/s. The output power obtained from the test as shown in Fig. 16.

Fig. 16 shows that turbine output power changed as the wind speed changed. It can be seen that the output power generated when the wind variations occur is always at the maximum power, compared with MPPT results with the filter

on the test with 100 Ohm 100 watts resistor load in the previous section. The turbine output power is around 20 watts the wind speed 3 m/s, about 80 watt for the wind speed 6 m/s, and 150 watts for the wind speed of 8 m/s.

CONCLUSIONS

The design of maximum power point tracking system in wind turbine has been successfully built and executed in controlling the maximum output power of wind turbine. Applying filter algorithm to the input voltage (Vdc) and input current (IDC) produces better MPPT calculation. The results show that the duty cycle calculation is more stable using MPPT algorithm with the filter. Therefore, the output of power calculation becomes higher.

ACKNOWLEDGMENT

Thanks to the Universitas Indonesia, which has funded this research.

REFERENCES

- [1] Dipesh Kumar, Kalyan Chatterjee, "A review of conventional and advanced MPPT algorithms for wind energy system", *Renewable and sustainable energy reviews* 2016; 55:957-970.
- [2] Liang R-H, Liao J-H. A fuzzy-optimization approach for generation scheduling with wind and solar energy systems. *IEEE Trans Power Syst* 2007;22:1665-74.
- [3] Saber AY, Venayagamoorthy GK. Efficient utilization of renewable energy sources by gridable vehicles in cyber-physical energy systems. *IEEE J* 2010;4:285-94.
- [4] Nikolova S, Causevski A, Al-Salaymeh A. Optimal operation of conventional power plants in power system with integrated renewable energy sources. *Energy Convers Manag* 2013;65:697-703.
- [5] Bansal M, Khatod DK, Saini RP. Modeling and optimization of integrated renewable energy system for a rural site. *Int Conf Reliab* 2014;25-8.
- [6] Böttger D, Götz M, Theofilidi M, Bruckner T. Control power provision with power-to-heat plants in systems with high shares of renewable energy sources – an illustrative analysis for Germany based on the use of electric boilers in district heating grids. *Energy* 2015;82:157-67.
- [7] Sahin.P, Resmi.R, V. Anitha, "PMSG Based Standalone Wind Electric Conversion System with MPPT", *International Conference on Emerging Technology Trend [ICETT]*, 2016.
- [8] Sudeshna Khan, "Modeling and Performance Analysis of a Direct Driven PMSG for Variable Speed Wind Energy Conversion System". Thesis, Purdue University, 2012.

Implementation of Maximum Power Point Tracking Algorithm on Wind Turbine Generator using Perturb and Observe Method

ORIGINALITY REPORT

25%
SIMILARITY INDEX

13%
INTERNET SOURCES

24%
PUBLICATIONS

%
STUDENT PAPERS

PRIMARY SOURCES

1 eprints.soton.ac.uk 1%
Internet Source

2 Ali H. Kasem Alaboudy, Ahmed A. Daoud, Sobhy S. Desouky, Ahmed A. Salem. 1%
"Converter controls and flicker study of PMSG-based grid connected wind turbines", Ain Shams Engineering Journal, 2013
Publication

3 Muhammad Ahlanur Ramadhan, Bernadeta Wuri Harini, Nanda Avianto, Feri Yusivar. 1%
"Implementation of maximum power point tracker algorithm based proportional-integrator controller on solar cell with boost converter circuit", 2017 International Conference on Sustainable Energy Engineering and Application (ICSEEA), 2017
Publication

4 P. Sahin, R. Resmi, V. Vanitha. "PMSG based standalone wind electric conversion system 1%

with MPPT", 2016 International Conference on Emerging Technological Trends (ICETT), 2016

Publication

5	www.scilit.net Internet Source	1 %
6	www.proceedings.com Internet Source	1 %
7	aip.scitation.org Internet Source	1 %
8	mdpi.com Internet Source	1 %
9	Renewable Energy in the Service of Mankind Vol I, 2015. Publication	1 %
10	res.mdpi.com Internet Source	1 %
11	orca.cf.ac.uk Internet Source	1 %
12	V. Vanitha, Nithya Ramesh, R. Resmi. "Hybrid Wind and Solar Based Battery Charging Controller", 2019 Innovations in Power and Advanced Computing Technologies (i-PACT), 2019 Publication	1 %
13	www.ijrer.ijrer.org Internet Source	1 %

14	pt.slideshare.net Internet Source	<1 %
15	pt.scribd.com Internet Source	<1 %
16	Yu Fang, Liu Qi-hui, Zhang Jian-hua. "Flexible Grid-connection Technique and Novel Maximum Wind Power Tracking Algorithm for Doubly-Fed Wind Power Generator", IECON 2007 - 33rd Annual Conference of the IEEE Industrial Electronics Society, 2007 Publication	<1 %
17	"Advances in Greener Energy Technologies", Springer Science and Business Media LLC, 2020 Publication	<1 %
18	Binayak Bhandari, Shiva Raj Poudel, Kyung-Tae Lee, Sung-Hoon Ahn. "Mathematical modeling of hybrid renewable energy system: A review on small hydro-solar-wind power generation", International Journal of Precision Engineering and Manufacturing-Green Technology, 2014 Publication	<1 %
19	Elahe Heydari, Ali Yazdian Varjani. "Combined modified P&O algorithm with improved direct power control method applied to single-stage three-phase grid-connected PV system", 2018	<1 %

9th Annual Power Electronics, Drives Systems and Technologies Conference (PEDSTC), 2018

Publication

20

Frede Blaabjerg, Dehong Xu, Wenjie Chen, Nan Zhu. "Advanced Control of Doubly Fed Induction Generator for Wind Power Systems", Wiley, 2018

Publication

<1 %

21

M. Firat Vural, Cemil Kiziloğlu, Emre Turgay. "FPGA based real-time efficient histogram equalization", 2009 IEEE 17th Signal Processing and Communications Applications Conference, 2009

Publication

<1 %

22

Zakaria Lammouchi, Youcef Bekakra. "Predictive Power Control for Photovoltaic Grid Connected System with Reduction of Switching Frequency", 020 1st International Conference on Communications, Control Systems and Signal Processing (CCSSP), 2020

Publication

<1 %

23

Edgar N. Sánchez, Larbi Djilali. "Neural Control of Renewable Electrical Power Systems", Springer Science and Business Media LLC, 2020

Publication

<1 %

24

ethesis.nitrkl.ac.in

Internet Source

<1 %

25

Hassan Fathabadi. "Novel highly accurate universal maximum power point tracker for maximum power extraction from hybrid fuel cell/photovoltaic/wind power generation systems", Energy, 2016

Publication

<1 %

26

Mahdi Delzendeh Sarfejo, Mohammadali Narooie Dehchil, Soheil Rahnamayian Jelodar. "MPPT Approach for Fixed Speed wind Turbine by Using Proportional-Integral Controller", 2019 27th Iranian Conference on Electrical Engineering (ICEE), 2019

Publication

<1 %

27

Nanda Avianto Wicaksono, Bernadeta Wuri Harini, Feri Yusivar. "Sensorless PMSM Control using Fifth Order EKF in Electric Vehicle Application", 2018 5th International Conference on Electrical Engineering, Computer Science and Informatics (EECSI), 2018

Publication

<1 %

28

Retno Wulandari, Solichin, Wahyu Puspa, Rangga Ega Santoso. "Investigation on the effect of rotor angle and wind velocity on the Savonius wind turbine", AIP Publishing, 2019

Publication

<1 %

29

Tai-Her Yeh. "A Study on Generator Capacity for Wind Turbines Under Various Tower

<1 %

Heights and Rated Wind Speeds Using Weibull Distribution", IEEE Transactions on Energy Conversion, 6/2008

Publication

30

www.iaescore.com

Internet Source

<1 %

31

www.intechopen.com

Internet Source

<1 %

32

A.H.M.A. Rahim. "DYNAMIC PERFORMANCE ENHANCEMENT OF A GRID-CONNECTED WIND GENERATION SYSTEM", International Journal of Modelling and Simulation, 2009

Publication

<1 %

33

J. Arau. "Analysis and experimental study of the buck, boost and buck-boost inverters", 30th Annual IEEE Power Electronics Specialists Conference Record (Cat No 99CH36321) PESC-99, 1999

Publication

<1 %

34

Qian Xie, Changhui Mu, Gang Wu, Zhibin Yu, Yanan Yu, Rong Jia. "Method for flux linkage optimization of permanent magnet synchronous motor based on nonlinear dynamic analysis", Nonlinear Dynamics, 2019

Publication

<1 %

35

S. Bhowmik, R. Spee, J.H.R. Enslin. "Performance optimization for doubly fed

<1 %

wind power generation systems", IEEE
Transactions on Industry Applications, 1999
Publication

36

scholar.utc.edu
Internet Source

<1 %

37

Alok Pratap, Naomitsu Urasaki, Tomonobu Senju. "Control Strategies for Smoothing of Output Power of Wind Energy Conversion Systems", International Journal of Emerging Electric Power Systems, 2013
Publication

<1 %

38

Apoorva Srivastava, Ram Sharan Bajpai. "An Efficient Maximum Power Extraction Algorithm for Wind Energy Conversion System Using Model Predictive Control", International Journal on Energy Conversion (IRECON), 2019
Publication

<1 %

39

Dipesh Kumar, Kalyan Chatterjee. "Artificial bee colony based MPPT algorithm for wind energy conversion system", 2016 IEEE 6th International Conference on Power Systems (ICPS), 2016
Publication

<1 %

40

Hassan Fathabadi. "Novel standalone hybrid solar/wind/fuel cell/battery power generation system", Energy, 2017
Publication

<1 %

41

K. Tan, T.T. Yao, S. Islam. "Effect of loss modeling on optimum operation of wind turbine energy conversion systems", 2005 International Power Engineering Conference, 2005

Publication

<1 %

42

Mohammed A. Qasim, Vladimir Ivanovich Velkin. "Maximum Power Point Tracking Techniques for Micro-Grid Hybrid Wind and Solar Energy Systems - a Review", International Journal on Energy Conversion (IRECON), 2020

Publication

<1 %

43

Wen Jiang, Zheng Yan, Zhi Hu. "A Novel Improved Particle Swarm Optimization Approach for Dynamic Economic Dispatch Incorporating Wind Power", Electric Power Components and Systems, 2011

Publication

<1 %

44

eprints.staffs.ac.uk

Internet Source

<1 %

45

vibdoc.com

Internet Source

<1 %

46

Adel M. Sharaf, Adel A. A. El-Gammal. "Chapter 9 Particle Swarm Optimization PSO: A New Search Tool in Power System and

<1 %

47

E. Muljadi, H.E. McKenna. "Power quality
issues in a hybrid power system", IEEE
Transactions on Industry Applications, 2002

Publication

<1 %

48

Emmanouil Alexis, Carolin CM Schulte, Luca
Cardelli, Antonis Papachristodoulou.
"Biomolecular mechanisms for signal
differentiation", Cold Spring Harbor
Laboratory, 2021

Publication

<1 %

49

Lazarus Stefan, Feri Yusivar. "Modeling of
Wind Turbine Generator with Boost Converter
MPPT", 2018 2nd International Conference on
Smart Grid and Smart Cities (ICSGSC), 2018

Publication

<1 %

50

M. Basu. "Heat and power generation
augmentation planning of isolated microgrid",
Energy, 2021

Publication

<1 %

51

Nien Tsu Chen, Poren Chung, Che Ming
Chiang, Kuang Sheng Liu, Cheng Chen Chen.
"A Discussion of the Impact of Building Wind
Deflector on Changes in Wind Field by Using
the Numerical Simulation", Applied Mechanics
and Materials, 2013

<1 %

52

Nishtha Verma, Sandeep Banerjee, Sanchita Gupta, Siddharth Goyal, Rahul Sharma.
"PMSG based WECS with MPPT via modified P & O algorithm", 2019 3rd International Conference on Recent Developments in Control, Automation & Power Engineering (RDCAPE), 2019

Publication

<1 %

53

R. Sakamoto, T. Senju, N. Urasaki, T. Funabashi, H. Fujita, H. Sekine. "Output Power Leveling of Wind Turbine Generators using Pitch Angle Control for All Operating Regions in Wind Farm", Proceedings of the 13th International Conference on, Intelligent Systems Application to Power Systems, 2005

Publication

<1 %

54

S.H. Karaki, R.B. Chedid, R. Ramadan.
"Probabilistic performance assessment of wind energy conversion systems", IEEE Transactions on Energy Conversion, 1999

Publication

<1 %

55

Shantanu Chakraborty. "Optimal Thermal Unit Commitment Integrated with Renewable Energy Sources Using Advanced Particle Swarm Optimization", IEEJ Transactions on Electrical and Electronic Engineering, 09/2009

Publication

<1 %

56

T. Sun, Z. Chen, F. Blaabjerg. "Flicker Study on Variable Speed Wind Turbines With Doubly Fed Induction Generators", IEEE Transactions on Energy Conversion, 2005

Publication

<1 %

57

www.academypublisher.com

Internet Source

<1 %

58

H. Li, Z. Chen. "Optimal direct-drive permanent magnet wind generator systems for different rated wind speeds", 2007 European Conference on Power Electronics and Applications, 2007

Publication

<1 %

59

Lecture Notes in Electrical Engineering, 2015.

Publication

<1 %

60

Jul-Ki Seok. "Variable speed wind power generation system based on fuzzy logic control for maximum output power tracking", 2004 IEEE 35th Annual Power Electronics Specialists Conference (IEEE Cat No 04CH37551), 2004

Publication

<1 %

61

Kazuo Yamamoto. "Transient Grounding Characteristics of an Actual Wind Turbine Generator System at a Low-resistivity Site", IEEJ Transactions on Electrical and Electronic Engineering, 01/2010

Publication

<1 %

62

Peter Jamieson. "Innovation in Wind Turbine Design", Wiley, 2011

Publication

<1 %

63

Wu Yichun, Ding Ming. "Optimal choice of wind turbine generator based on Monte-Carlo method", 2008 Third International Conference on Electric Utility Deregulation and Restructuring and Power Technologies, 2008

Publication

<1 %

Exclude quotes Off

Exclude matches Off

Exclude bibliography Off