International Journal of Advanced Computer Technology
ISSN: 2319-7900 www.ijact.org Volume-X, Issue-VI, December 2021

Wind Energy Conversion System With Permanent Magnetic Synchronous Generator

Bhupendra Singh Niranjan[1], Km Alka Verma[2], Km Pragati Grutam[3] Pradeep Kumar[4] Akash Tiwari[5]
Department of EE, MGIMT Lucknow India
[1]bhupendraorai@gmail.com,[2]alkav5132@gmail.com,[3]pragati.gautam2002@gmail.com,[4]pradeepmau72@gmail.com
[5]tiwariakash645@gmail.com

ABSTRACT:-*This paper presents a study on grid-connected WECS with PMSG. The application of non-conventional energy resources develops much rapidly to improve low carbon energy resources in India. Nowadays, we are going to depend on solar, wind for the fulfillment of energy demand. Wind energy applications develop much more rapidly than other renewable resources such as solar, geothermal, and so on in the 21st century. It becomes the third core energy resource following non-conventional fuels as oil and chemical. The electrical energy generated by wind power plants is the best developing and most promising renewable energy source. The wind is a clean, free, and limitless energy source. Wind Energy Generation Systems (WECS) are confronted with increasing demands for power quality and harmonic distortion control. With the advance in power electronics technology, the fast growth of variable speed WECS is now witnessed.*

KEYWORDS- WECS, PMSG.

1. INTRODUCTION

Among different types of renewable energy sources, wind energy is the cleanest and the most efficient energy source. The major advantages of wind energy are that wind-generated electricity doesn't pollute the water, air, or soil, doesn't contribute to global warming, and doesn't consume a large amount of water needed by other energy sources. It is caused by everyday solar radiation. Its supply is abundant, unlike solar power during bad weather conditions and nighttime. The price of electricity generation by the wind power plant is comparatively lesser than other modes of generation. It contributes to the economy of the middle class and low-class communities. It also creates employment opportunities for highly skilled workers. It's very fast and easy to install. In a year, many large utility-scale wind power plants are installed. There are different components of a SWECS, of which the most important is the type of generator used. There are several types of generators used, such as Self-excited induction generator (SEIG), doubly fed Induction generator (DFIG), and permanent magnet synchronous generator (PMSG)[1]. Among these generators, PMSG has several advantages which make it very usable for WECS. It doesn't require an additional dc supply for the excitation circuit. By eliminating the excitation, energy savings of 20% can be had by simply using magnets. It doesn't use slip rings, so it is simpler and maintenance-free.

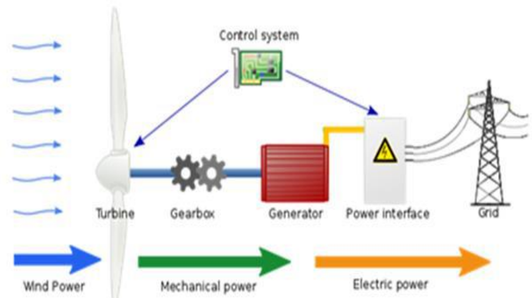

Figure 1 Generation of Wind Power

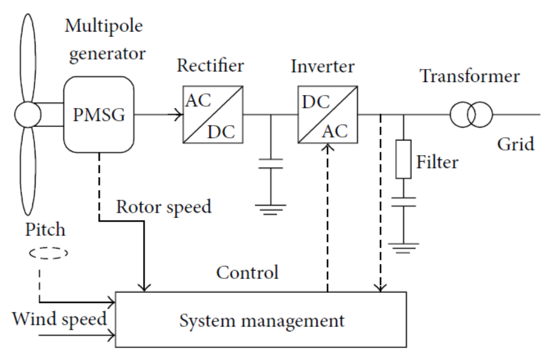

Figure 2 Block diagram representation of Wind Energy Conversion System

The condensers are not required for power factor maintenance, unlike induction generators, which is also an advantageous over-geared driven segment IG system. An induction generator requires leading reactive power to build up terminal voltage. On the other hand, DFIG has a shorter range of operation, unlike PMSG. It is quite complex management of LVRT in wind farms. LVRT is a wind turbine's low voltage ride-through capacity: the ability to overcome severe voltage dips on the main grid without turning off[2]. The basic device in the wind energy conversion system is the wind turbine which transfers the kinetic energy into mechanical energy. The wind turbine is connected to the electrical generator through a coupling device gear train. The output of the generator is given to the electrical grid by employing a proper controller to avoid disturbances and to protect the system or network[3]. The general layout and Block diagram of WECS is shown in figure 1and 2.

1. SYNCHRONOUS GENERATOR:

The synchronous generator is a synchronous electro-mechanical machine used as a generator and consists of a magnetic field on the rotor that rotates and a stationary stator containing multiple windings that supply the generated power. The rotor's magnetic field system (excitation) is created by using either permanent magnets mounted directly onto the rotor or energized electro-magnetically by an external direct-current flowing in the rotor field windings[5]. This DC field current is transmitted to the synchronous machine's rotor via slip rings and carbon or graphite brushes. Unlike the previous DC generator design, synchronous generators do not require complex commutation allowing for a simpler construction. Then the synchronous generator operates in a similar way to the automotive car alternator and consists of the two following common parts:

The Stator: – The stator carries the three separate (3-phase) armature windings physically and electrically displaced from each other by 120 degrees producing an AC voltage output.

The Rotor: – The rotor carries the magnetic field either as permanent magnets or wound field coils connected to an external DC power source via slip rings and carbon brushes.

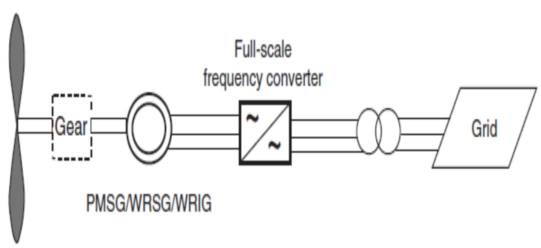

Figure 3 WECS with Synchronous Generator

The synchronous generator has two types:

2.1.WOUND ROTOR GENERATOR

The stator windings of WRSGs are connected directly to the grid, and hence the rotational speed is strictly fixed by the frequency of the supply grid. The rotor winding is excited with direct current using slip rings and brushes or a brushless exciter with a rotating rectifier. Unlike the induction generator, the synchronous generator does not need any other reactive power compensation system. The rotor winding, through which direct current flows, generates the exciter field, which rotates with synchronous speed[4]. The synchronous generator's speed is determined by the frequency of the rotating field and by the number of pole pairs of the rotor[8].

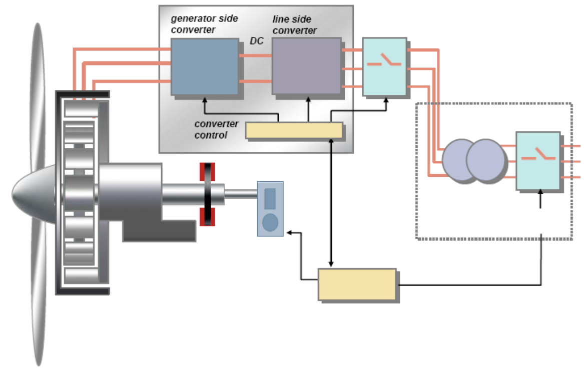

Figure 4 Systematic Diagram of PMSG

2.2 PERMANENT MAGNET GENERATOR

The efficiency of the permanent magnet machine is higher than in the induction machine, as the excitation is provided without any energy supply. However, the materials used for producing permanent magnets are expensive, and they are difficult to work during manufacturing. Additionally, the use of PM excitation requires a full-scale power converter to adjust the voltage and frequency of generation to the voltage and the frequency of transmission, respectively[8]. It is an added expense. However, the benefit is that power can be generated at any speed to fit the current conditions. A short introduction, presenting the basic wind turbine topologies and control strategies, was followed by the state of the art of wind turbines from an electrical point of view.nBased on technical aspects and market trends, old and new potential promising generators and power electronics concepts were presented. The introduction of variable-speed options in wind turbines increases the number of applicable generator types and introduces several degrees of freedom in the combination of generator and power converter types [9]. A significant trend for wind turbines is that large wind farms have to behave as integral parts of the electrical power system and develop power plant characteristics. Power electronic devices are promising technical solutions to provide wind power installations with power system control capabilities and improve power system stability[6, 7].

3. ADVANTAGE OF PMSG

- Usually low speed, so no gearbox
- Easy to control using a variable speed drive converter
- Fewer components and higher availability
- Average availability exceeding 98% lower maintenance cost
- Higher Partial load Efficiency
- 5-7 % higher energy production due to permanent magnetic excitation[9].

4. SIMULINK MODEL AND RESULT

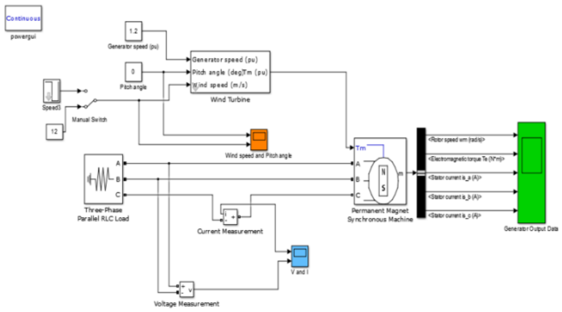

Figure 5 Simulink model of SWECS with VF controller

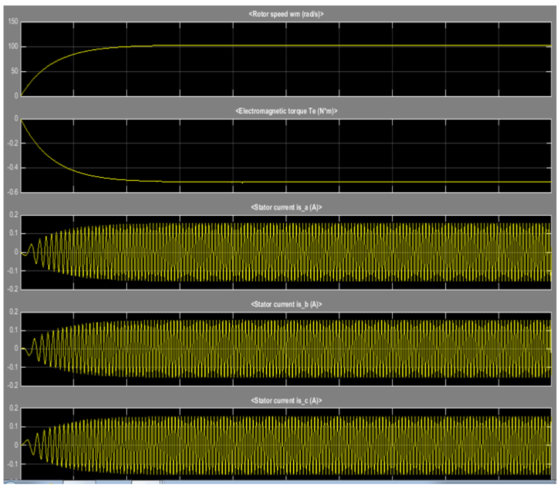

Figure 6 Output Waveform of WECS with PMSG

5. CONCLUSION

The PMSG based WECS was modeled and simulated using MATLAB & SIMULINK. The P&O MPPT control technique was implemented using a boost converter. Wind speed was varied in a step-up manner from 8 m/sec to 10 m/sec, and the controller's response was recorded. The plots of generated output power, dc-link voltage, and output three-phase voltage were recorded. The proposed model is run for 5 sec first without MPPT control and then with MPPT control. The power generated without an MPPT controller was low, i.e., 4.5 kW, and the power generated with an MPPT controller was around 6 kW. It shows the improvement in the conversion efficiency of the controller. Most of the power loss occurs in VSC switches and converters. The proposed MPPT method is utilized, and it is seen that the efficiency of power conversion is increased to around 40%.

REFERENCES

[1]. L. Pattathurani, Rajat Kumar Dwivedi, Dr.S.S.Dash, Matrix converter technology for wind energy conversion system, IJRASET, Volume 4 Issue X, October 2016.

[2]. Brekken, T. K. A., and Mohan, N. (2007). 'Control of doubly fed induction wind generator under unbalanced grid voltage conditions,' IEEE Transaction on Power Electronics, Vol. 22, no. 1, pp. 129-135.

[3]. Marinelli ,M., Morini, A., Pitto, A., and Silvestro, F., (2008). 'Modeling of doubly fed induction generator (DFIG) equipped wind turbine for dynamic studies,' 43rd International Universities Power Engineering Conference, Padova, Italy, pp. 1-6.

[4]. Ibrahima, K., Chegyong Zhao, (2011). 'Modeling of wind energy conversion system using doubly-fed induction generator equipped batteries energy storage system,' 4th International Conference on Electric Utility Deregulation and Restructuring and Power Technologies (DPRT), Weihai China, pp. 1780-1787.

[5]. E. Koutroulis and K. Kalaitzakis, "Design of a maximum power tracking system for wind-energy-conversion applications," IEEE Transactions on Industrial Electronics, vol. 53, no. 2, pp. 486–494, 2006.

[6]. R. Datta and V. T. Ranganathan, "A method of tracking the peak power points for a variable speed wind energy conversion system," IEEE Transactions on Energy Conversion, vol. 18, no. 1, pp. 163–168, 2003.

[7]. A. M. De Broe, S. Drouilhet, and V. Gevorgian, "A peak power tracker for small wind turbines in battery charging applications," IEEE Transactions on Energy Conversion, vol. 14, no. 4, pp. 1630–1635, 1999.

[8]. Q.Wang and L. Chang, "Independent maximum power extraction strategy for wind energy conversion systems," in Proceedings of the 1999 IEEE Canadian Conference on Electrical and Computer Engineering, vol. 2, pp. 1142–1147, May 1999.

[9]. A. Rol'an,' A. Luna, G. Vazquez, D. Aguilar, and G. Azevedo, "Modeling of a variable speed wind turbine with a permanent magnet synchronous generator," in Proceedings of the IEEE International Symposium on Industrial Electronics (ISIE' 09), pp. 734–739, July 2009.

AUTHORS PROFILE

Km Alka Verma- Pursuing B Tech(EE) Final Year From MGIMT Lucknow UP, Affiliated AKTU Lucknow.

	**Km Pragati Grutam -** Pursuing B Tech(EE) Final Year From MGIMT Lucknow UP, Affiliated AKTU Lucknow.
	**Pradeep Kumar -** Pursuing B Tech(EE) Final Year From MGIMT Lucknow UP, Affiliated AKTU Lucknow.
	**Akash Tiwari-** Pursuing B Tech(EE) Final Year From MGIMT Lucknow UP, Affiliated AKTU Lucknow.