CONTROL AND DESIGN OF DOUBLY FED INDUCTION GENERATOR- A REVIEW

Ashwani Kumar Mishra[1],Hemraj[2], Vasant Acharya[3]

Email:ashwanimishra9117@gmail.com[1], **hemrajee95@gmail.com[2]**,***Vasantacharyatitc@gmail.com[3]***

[1]M.Tech Scholar, Department of Electrical and Electronics Engineering, Technocrats Institute ofTechnology, Bhopal, India

[2]M.Tech Scholar, Department of Electrical and Electronics Engineering, Technocrats Institute ofTechnology, Bhopal, India

[3]Associate professor, Department of Electrical & Electronics Engineering, Technocrats Institute of Technology, Bhopal,India

ABSTRACT:

As the power generation from renewable resources are increasing, its technological development is also present a boom in its applications. Wind power is a widely adopted source of renewable energy. For increased performance efficiency in wind power technology, Doubly Fed Induction Generator (DFIG) is widely adopted. Since it has a variable speed characteristic. This means it can generate constant voltage for variable speed conditions. The rotor and stator of DFIG can be independently controlled via converters hence it has a good efficiency as well as power quality of the grid can also be enhanced. This paper presents the general overview and control architecture with constructional details for DFIG. DFIG has very complex architecture it is controlled via dual converter connected grid side of the turbine as well as rotor side. Hence its control is also complex. This paper presents the overview on control and design of DFIG.

KEYWORDS:***Doubly fed induction generator (DFIG), wind power generation system (WPGS), Point of common coupling (PCC), Voltage source converter (VSC), Rotor side converter (RSC), Grid side converter (GSC).***

1. INTRODUCTION

The expansion in wind control entrance, at 456 GW as of June 2016, has brought about more stringent framework codes which determine that the wind vitality transformation frameworks (WECS) must stay associated with the system during and after a fault and, further-more, must offer support of reactive power to stabilize grid operation and control [1]. DFIG-WECS is a well-demonstrated innovation, having been being used in wind control age for a long time and having an expansive world piece of the overall industry because of its many benefits [2-5].

Operation of wind turbines can becarried outby keeping speed either fixed or variable. With fixed speed turbines, the generator (specifically induction) is coupled with grid directly [6]. This type of WECS supply constant power to the grid, and can't be controlled, be that as it may, the disturbance of the breeze will result in power varieties, and along these lines influence the power nature of the grid. Advance high ratingturbines have capabilitiesto operate both in fixed and variable speedand applicable both as singly-fed induction generator(SFIG) or DFIG systems [7]. This technology can harnessmaximum energy from the wind even at low windspeeds by optimizing the turbine speed, whileminimizing mechanical stresses on the turbineenduring gusts of wind [8].

This paper presents the review on general introduction and operating principle for DFIG. It also covers real issues identified with the DFIG WECS that are an unquestionable requirement for an outline of the framework and subsequently fill in as a presentation particularly for new contestants into this region of study.

2. DOUIBLY FED INDUCTION GENERATOR (DFIG)

Doubly Fed Induction Generator, as the name suggests got two winding; magnetic field winding and armature winding which are separately connected to external equipments. The working principle is same as all the rotating machines has. Fig-1 shows the constructional feature of DFIG. AC generators and DFIG are similar in constructional features but, DFIG is different in a sense that it can be operated at variable speed that’s why they are sustainable as variable speed wind generation system. The DFIG is a combination of four technologies aerodynamic, mechanical, electromagnetic, and electronic systems [9].

Due to the ability of DFIG to operate in a variable wind speed conditions, its application as a wind power generation system is increasing day by day. The DFIG’s principle of working as an induction generator with a multiphase wound rotor and a multiphase slip ring assembly with brushes for access to the rotor windings. As mentioned earlier, DFIG is fed from two ends, one end of the generator is connected to the grid and another end is to the two back to back voltage source converters (VSC). The VSC is designed using three phase 2 level universal bridge with three arms as shown in figure 1. Both the inverters are linked with Dc link capacitor to stop circulation of leakage current and proper matching of inverters. At both the ends of converter filters are connected. Generator has two windings; one winding is directly connected to the output, and produces 3-phase AC power at the desired grid frequency. The other winding (traditionally called the field, but here both windings can be outputs) is connected to 3-phase AC power at variable frequency[10]. This input power is adjusted in frequency and phase to compensate for changes in speed of the turbine.

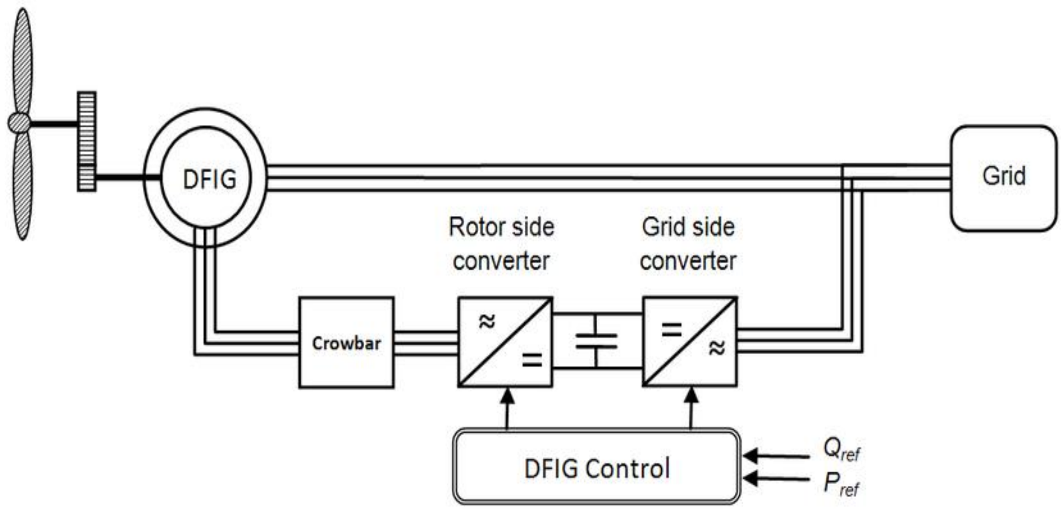

Fig. 1 **Schematic of a DFIG connected to a wind turbine.**

3. CONSTRUCTION OF DFIG

AC generators and DFIG are similar in constructional features but, DFIG is different in a sense that it can be operated at variable speed that's why they are sustainable as variable speed wind generation system. The DFIG is a combination of four technologies as mentioned below [11];

1. Aerodynamic,
2. Mechanical,
3. Electromagnetic, and
4. Electronic Systems

Figure 2 shows the cross-sectional view of DFIG. The main components of the system are shown in table 1

4. WORKING PRINCIPLE OF DFIG

Due to the ability of DFIG to operate in a variable wind speed conditions, its application as a wind power generation system is increasing day by day. The DFIG's principle of working as an induction generator with a multiphase wound rotor and a multiphase slip ring assembly with brushes for access to the rotor windings. The basic construction principle comprises of rotor mounted on a shafted connected to the generator through the gear box as shown in Figure-3.2 [12]. As mentioned earlier, DFIG is fed from two ends, one end of the generator is connected to the grid and another end is to the two back to back voltage source converters (VSC). The constructional details of VSC are shown in Figure3. The VSC is designed using three phase 2 level universal bridge with three arms. Both the inverters are linked with Dc link capacitor to stop circulation of leakage current and proper matching of inverters. At both the ends of converter filters are connected whose parameters are mentioned in Table 3.2. Generator has two windings; one winding is directly connected to the output, and produces 3-phase AC power at the desired grid frequency. At variable frequency, the winding is connected to 3-phase AC power. This input power is adjusted in phase and frequency compensating for changes in speed of the turbine [13].

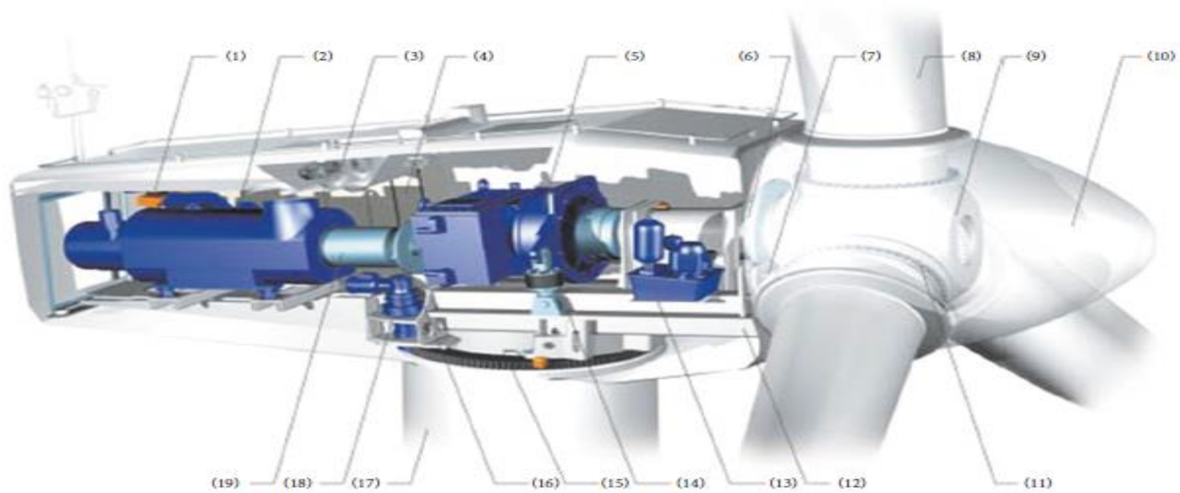

Fig. 2Cross-sectional view of DFIG

Table 1. Components of DFIG

(1) Service crane	(11) Blade bearing.
(2) Generator.	(12) Bed frame.
(3) Cooling system.	(13) Hydraulic unit.
(4) Top control unit.	(14) Shock absorbers.
(5) Gearbox.	(15) Yaw ring.
(6)Main shaft with two bearings.	(16) Brake.
(7) Rotor lock system.	(17) Tower.
(8) Blade.	(18) Yaw gears.
(9) Hub.	(19) Transmission high speed shaft.
(10) Hub cover.	

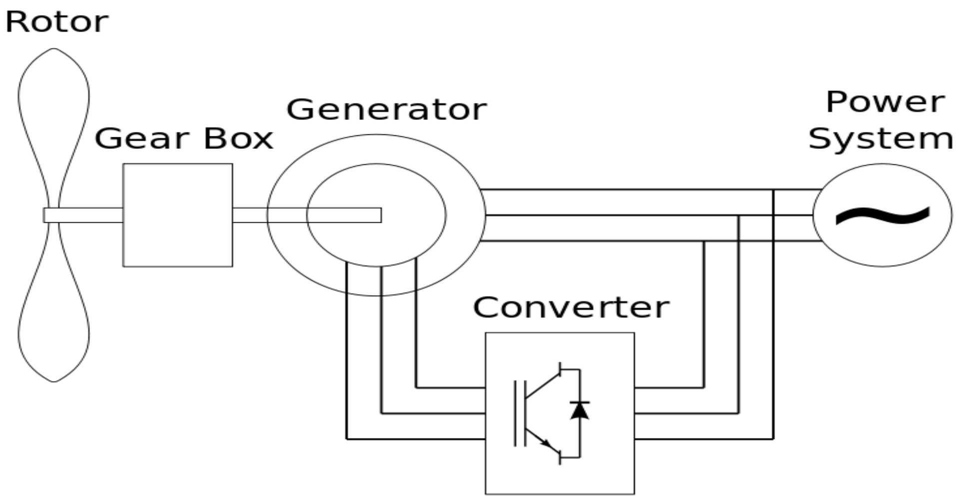

Fig. 3 **Principle of a DFIG connected to a wind turbine**

The topology to design control mechanism of the DFIG-WECS is governed by the characteristics and functionality of the turbine, the gearbox, the drive shaft, and the generator [14]. All these components are termed as power drive train collectively. For the proper management of the control of DFIG, a supervisory control is designed which up-to-date the minute to year data of wind speed to match the system control [15]. It carries out the task mentioned below (Table-2). The control architecture of DFIG is shown in figure 4 [16].

Table 2.The control functions of supervisory system

States	Task
Initialization	Monitoring wind and other loading conditions
Status update	sending information to the control system
Monitoring	monitoring operation for safe conditions, monitoring grid conditions
Actuation	Actuating emergency systems, and switching between operating states that facilitate connection and disconnection to the grid.

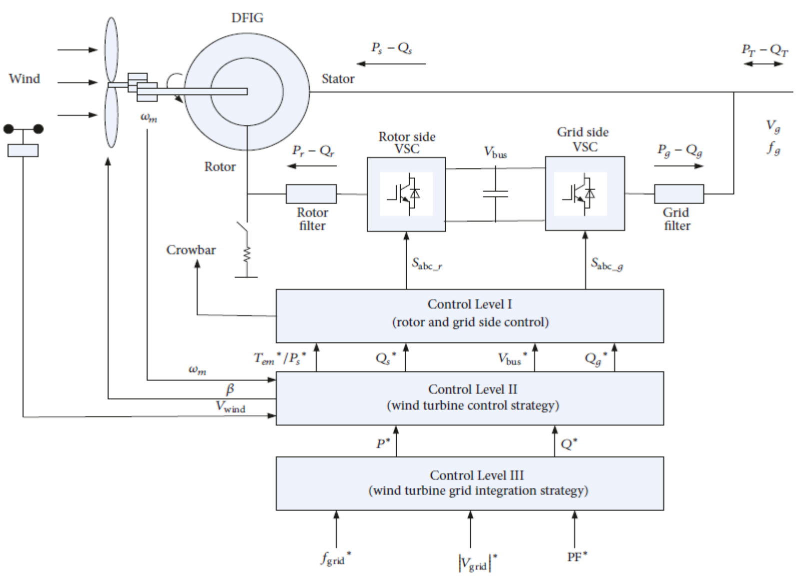

Fig. 4General architecture of DFIG grid connected system

5. CONCLUSION

Energy Development Through Resources Can Be Incredible Because It Is A Green Energy. Wind Generator Is A Renewal Source Of Continuous Facilities. In Wind System, Dfig Is Widely Addited As It Is A Various Speed And It's Rotor Is Controlled By A Power Source Converter That Helps Supply Supplied Power Supply Of System. Also, DFIG Has Low Loss Compared To Other Wind Generation Systems. This Document Provides An Overview Of Dfig Building, Control And Operation Principles. The Components For Building DFIG To Be Used In The DFIG are Displayed In Details With Section View.

REFERENCES

[1] T. Wang and H. Nian, "Flexible PCC voltage unbalance compensation strategy for autonomous operation of parallel DFIGs," in Proc. IEEE Energy Convers.Congr.Expo., Milwaukee, WI, 2016, pp. 1–6.

[2] Song, Y., &Blaabjerg, F. (2016). Overview of DFIG-based wind power system resonances under weak networks.IEEE Transactions on Power Electronics, 32(6), 4370-4394.

[3] Y. Wang and L. Xu, "Coordinated control of DFIG and FSIG-based wind farms under unbalanced grid conditions," IEEE Trans. Power Del., vol. 25, no. 1, pp. 367–377, Jan. 2010.

[4] H. Nian, T. Wang, and Z. Q. Zhu, "Voltage imbalance compensation for doubly fed induction generator using direct resonant feedback regulator," IEEE Trans. Energy Convers., vol. 31, no. 2, pp. 614–626, Jun. 2016.

[5]Glinkowski, M., Hou, J., &Rackliffe, G. (2011). Advances in wind energy technologies in the context of smart grid. Proceedings of the IEEE, 99(6), 1083-1097.

[6] J. He, Y. W. Li, and F. Blaabjerg, "An enhanced islanding microgrid reactive power, imbalance power, and harmonic power sharing scheme," IEEE Trans. Power Electron., vol. 30, no. 6, pp. 3389–3401, Jun. 2015.

[7] Wang, X., Yang, D., &Blaabjerg, F. (2017, October). Harmonic current control for LCL-filtered VSCs connected to ultra-weak grids. In 2017 IEEE Energy Conversion Congress and Exposition (ECCE) (pp. 1608-1614). IEEE.

[8]Skander-Mustapha, S., &Slama-Belkhodja, I. (2011, March). Supervisory for parallel operation of two DFIG-based wind farm using variable wind speeds. In Eighth International Multi-Conference on Systems, Signals & Devices (pp. 1-6).IEEE.

[9]Wang, L., &Thi, M. S. N. (2013). Comparative stability analysis of offshore wind and marine-current farms feeding into a power grid using HVDC links and HVAC line.IEEE Transactions on Power Delivery, 28(4), 2162-2171.

[10]Goel, P. K., Singh, B., Murthy, S. S., & Kishore, N. (2010, December). Modeling and control of autonomous wind energy conversion system with doubly fed induction generator. In 2010 Joint International Conference on Power Electronics, Drives and Energy Systems & 2010 Power India (pp. 1-8). IEEE.

[11] S. Liu, X. Wang, and P. X. Liu, "Impact of communication delays on secondary frequency control in an islanded microgrid," IEEE Trans. Ind. Electron., vol. 62, no. 4, pp. 2021–2031, Apr. 2015.

[12] C. Ahumada, R. C´ardenas, D. S´aez, and J. M. Guerrero, "Secondary control strategies for frequency restoration in islanded microgrids with consideration of communication delays," IEEE Trans. Smart Grid, vol. 7, no. 3, pp. 1430–1441, May 2016.

[13]M. Savaghebi,A. Jalilian, J. C.Vasquez, and J.M.Guerrero, "Autonomous voltage unbalance compensation in an islanded droop-controlled microgrid," IEEE Trans. Power Electron., vol. 60, no. 4, pp. 1390–1402, Apr. 2013.

[14] P. Sreekumar and V. Khadkikar, "A new virtual harmonic impedance scheme for harmonic power sharing in an islanded microgrid," IEEE Trans. Power Del., vol. 31, no. 3, pp. 936–945, Jun. 2016.

[15] X. Wang, F. Blaabjerg, and Z. Chen, "Autonomous control of inverter interfaced distributed generation units for harmonic current filtering and resonance damping in an islanded microgrid," IEEE Trans. Ind. Appl., vol. 50, no. 1, pp. 452–461, Jan. 2014.

[16] J. He, Y. W. Li, and M. S. Munir, "A flexible harmonic control approach through voltage-controlled DG–grid interfacing converters," IEEE Trans. Ind. Electron., vol. 59, no. 1, pp. 444–455, Jan. 2012.