International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue 10
September 2017

Control of Reactive Power in Doubly Fed Induction Generator Wind Turbine System

R.Chander and Menchu Sreepunya

[1]Research Scholar Department of Electrical Engineering University College of Engineering (A) Osmania University,Hyderabad Telangana,India
E-mail:chander.ramavath@gmail.com

[2]M.Tech student, P.E Chaitanya Institute of Technology and Science
Warangal, Telangana,India
E-mail: sreepunya9.menchu@gmail.com

ABSTRACT: Doubly fed induction generators (DFIG) based wind turbine is an emerging technology, which becomes increasingly popular due to its various advantages over fixed speed generator systems. A DFIG based wind turbine has an ability to generate maximum power with varying and adjustable speed, ability to control active and reactive power by the integration of electronic power converters, low power rating of cost converter components, and so on. This study presents an overview and literature survey over past few decades on the different problems associated due to penetration of WT-DFIG in the power system and control aspects of DFIG.The doubly-fedinduction generator (DFIG) is widely used in wind farms because it has many advantages. The reactive powercontrol is mainly achieved by two modes, i.e. power factor control and voltage control.

KEYWORDS: DFIG, WTS, Reactive power compensationtor.

I. INTRODUCTION

World's largest sum of electricity generation contributed by non-renewable sources of fuel such as coal, gas and oil.These fuels emit lots of CO2 other harmful gases to the atmosphere and their residues in the water, which raised globalwarming issues of earth health problems of human and wild-life issues[7]. According to FatihBirol, Chief Economist,International Energy Agency of the Organisation for Economic Cooperation and Development (IEA), world electricitydemand is projected to double between 2000 and 2030, growing at an annual rate of 2.4%. This is faster than any otherenergy demand. Total share of electric energy consumption rises from 18% in 2000 to 22% in 2030. Electricitydemand growth is strongest in developing countries, where demand will climb by over 4% per year over the projectedperiod, which gets more than triple by 2030. Consequently, the electric energy demand in developing countries willrise global electricity share from 27% in 2000 to 43% in 2030[2]. Non-renewable resources also depreciating inreserve each year and not long-lasting. Their purchasing cost increasing day by day and it would become unaffordableto developing countries. So, these countries have to face unbalance between demand and blackouts. Some developedcountries also have faced some blackouts in the past. This harms drastically their economy. Hence cost, availabilityand environmental pollution and health issues become the limiting factor for these fuels. No, doubt we can go fornuclear fusion (H+H =He + abundant source of energy but nobody knows when we able control it?) and nuclearfission (Pl and Uranium on splits as chain reaction gives a large amount of heat energy and harmful radiating residues

which is the major cause of health problems for any country as already faced by Japan and Russia) .The earthdisturbances, human population and atmospheric are still limiting factors for nuclear fission. In present scenario tocope up the demand of electricity, we must have to divert for another solution. So, solution of this critical situationwould be provided by the natural resources. These resources characterized as renewable energy resources such asWind, solar, hydro, Geo and Bio-gas. In past few decades there is a lot of research findings to capture these energiesand new technologies being listed by researches [1-3].

International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue 10
September 2017

Out of these resources wind energy conversion systems(WECS) becomes so much popular in the world.

Out of the above natural sources wind energy conversion systems include less conversion equipment, land need, lessmaintenance, direct coupling of wind turbine to generator shaft. There So many WECS technologies availableclassified as: fixed speed and variable speed WECS. Fixed speed employed Squirrel Cage Induction Generator(SCIG)as mechanical to electricity conversion element with soft starter technology simple to construct but may affect steadystate stability of power system under unbalanced conditions such as gust in wind, voltage dip in the bus bar voltage ,and Need a stiff power grid and not tolerated by weak Grid [1-6].Variable speed WECS employed mainly twotechnologies such as SCIG in which Capacitor bank and soft-starter are replaced by a full scale converter. It requires100% rating of power stability equipment (FACTS for power factor correction) as that of generator rating.

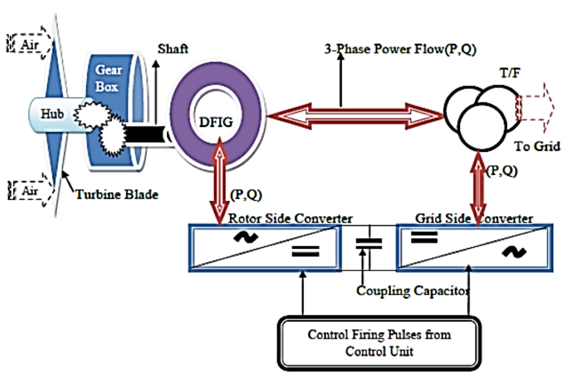

Fig.1DFIG with power converter

It gives stillless effective steady state stability measures as constrained by high cost of converter[1,4,5]. Second technology ofvariable WECS is Doubly Fed Induction Generator (DFIG) based wind power to electricity conversion element asshown in fig. 1. This technology becomes so much popular and opted by maximum number of countries in the world.There are following advantages listed for DFIG based WECS [4-6]:

- Converter system provides reactive power compensation and smooth grid integration.
- The market shareof DFIG systems (75%) many times the any other types of WECS.
- Around 86% patents are on controlling of DFIG. Woodward filed 10 patent applications in the same field in year 2010, as it has no previous record of Intellectual Property activity.
- Converter Rating is only 25%-30% inDFIG as compared to 100 % of total nominal power of the generator.
- Stator feeds the remaining 70%-75% of total power directly into the grid.
- Wider range of variable speed of approximately ± 30% around synchronous speed.

In the present scenario due to penetration of large number of DFIG based WECS and interconnection to main gridsgives rise to new steady state stability challenges for the researchers and scientists due to some power regulating issuesunder unbalance conditions such as Voltage sags or faults which occur in the network makes performance poor, faultride-through(FRT), Low voltage ride through (LVRT) capabilities of DFIGWTs under transient periods, Inter areaoscillations in long distance transmission to keep up constant output power to grid and to extract maximum powerfrom continually fluctuating power, Sub-synchronous resonance (SSR) occurred in series compensated electricalnetworks becomes new area of research with DFIGWTs connected to series compensated networks, Large oscillationsof the DC-link voltage cannot be avoided as the grid side converter controller was not optimized, Suitable choice ofInsulated gate bipolar transistor (IGBT for converter equipment) thermal impedances, Small-Signal Stability Problemsand steady state problems. Some other issues are also taken as research finding by the researchers such as converter'sbattery energy system optimization (BES), stator's harmonic current control, Direct torque control, amplitudefrequency control, load frequency control, open loop rotor control, Control based inertia contributed by DFIG,Hysteresis-Based Current Regulators and Dynamic Stability control using FACTS.

II. PROPOSEDCONTROL STRATEGY

DFIG wind turbine has the capability of absorbing as well as generating reactive power, a DFIG windfarm thus can not only generate active power, but also generate or absorb the reactive power to stabilize the gridvoltage. The reactive power is mainly controlled by power factor control mode and voltage control mode.Some reactive power compensation techniques used in DFIG wind turbine systems are explained below.The customary reactive power remuneration gadgets like STATCOM and SVC will build expenses ofthe wind cultivate. The STATCOM and the SVC plays out similar capacities. Yet, STATCOM have a largernumber of favorable circumstances than SVC. The STATCOM can create more responsive power at voltageslower than the ordinary voltage direction go, than SVC. Since the most extreme capacitive power created by theSVC is corresponding to the square of the framework voltage. This is one vital preferred standpoint of theSTATCOM over the SVC. Likewise, the STATCOM will likewise display a speedier reaction than the SVC.Since, the STATCOM has no deferral related with the terminating of thyristor.Another strategy for reactive power control in DFIG wind turbine is SFO vector control. The designcomprises of the consecutive two level SPWM converters. One is utilized for RSC and another is utilized forGSC. The control of DFIG is accomplished by controlling the RSC and the GSC. The fundamental goal of theRSC is to controls the dynamic (Ps) and responsive power (Qs). The point of the GSC is to keep up the DCconnect voltage (Vdc) as steady .The vector control of the SFO is corresponding to the present controller. Thatis ,by managing rotor streams in direct and quadrature pivot the control of the dynamic power (Ps) andresponsive power (Qs) is accomplished and additionally rotor speed of the generator is controlled, subsequentlycontrol variable can be controlled.

To enhance the participation of DFIG WTS for voltage regulation, by enabling load balancing andreactive power support to the grid. For this purpose, derives the optimal power coefficient of the wind turbinesystem that allows reactive or unbalanced power compensation and optimal power injection simultaneously.Furthermore, as the interaction between the different sequence components of the current in both the stator andthe rotor causes oscillating torque leading to mechanical strain on the drive-train, the unbalanced power iscompensated by the GSC. The RSC is controlled to adjust the active and reactive power of the stator. Theoptimal power coefficient is derived based on the steady-state power capability of the DFIG-GSC.For regulating reactive power in DFIG wind farm, a certain number of DFIG wind turbines are selectedaccording to the up and down limitations to inject the demanded reactive power into the grid.In DFIG wind farmthus can not only generate active power, but also generate or absorb the reactive power to stabilize the gridvoltage. The reactive power is mainly controlled in two modes, i.e. power factor control and voltage control.Both the two modes take the point of common coupling (PCC) as the reference point. The voltage or powerfactor at Point of Common Coupling is detected and it is compared with the reference to calculate the reactivepower demanded by the grid. Based on the demanded reactive power and the reactive power the number ofDFIGs involved is determined.

A. Loss Model of the DFIG System

However, this approachnot only affects the loss of the RSC, but also imposes the lossof the DFIG itself.Loss dissipation inside the induction generator generally consists of the copper loss and iron loss as shown in Fig.2 [18]. Ifthe stator voltage-oriented vector control is applied, the statorside active power P_s and reactive power Q_s are independentlyin line with the stator d-axis current isd and q-axis current i_{sq}.

International Journal of Research
Available at https://edupediapublications.org/journals

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue 10
September 2017

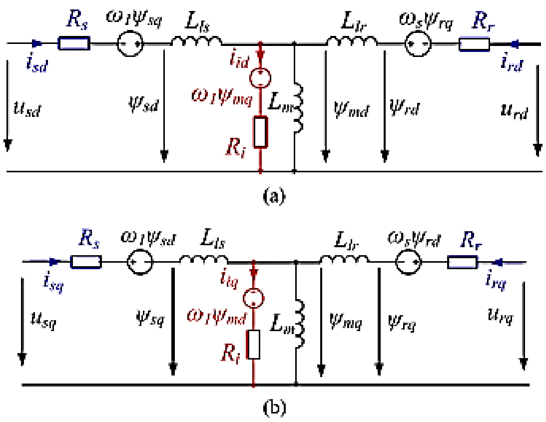

Fig. 2 DFIG equivalent circuit considering copper loss and iron loss.(a) d-axis circuit. (b) q-axis circuit.

In respect to the losses of the power converters in the DFIGsystem, it is well described in [16]. If the reactive power isprovided by the RSC, the loss model of the generator (copperloss and iron loss) and the RSC (conduction loss and switchingloss both in the IGBT and the freewheeling diode) is shown inFig. 3(a). It is evident that if the references of the active power,reactive power, and slip are known in advance, together with theinformation of the generator and power switching devices, eachtype of the losses can be analytically calculated.

With the aid from the GSC, another approach may be realizedto compensate the reactive power, which stresses the GSC andaffects the loss of the GSC and the filter. Compared with theGSC losses, the grid filter loss is small enough [21], and it issimply calculated by its parasitic equivalent series resistance (ESR). Similarly, as the conduction loss and switching loss ofthe IGBT and the diode are analytically solved, the GSC losscan be calculated as shown in Fig. 3(b).

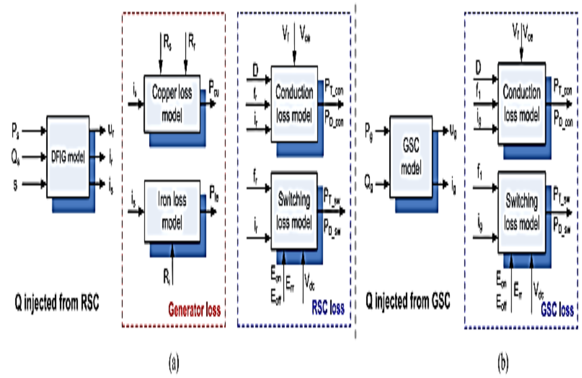

Fig. 3. Framework of power loss estimation. (a) Reactive power is injected by the RSC. (b) Reactive power is injected by the GSC.

III. CONCLUSION

The DFIG framework has a greater number of focal points however high cost than settled speedacceptance generators without converters. Likewise the controllability and execution of DFIG wind turbines arephenomenal. They catch more wind vitality, display a higher dependability adapt framework, and excellentpower provided to the matrix. Due to the existence of the two possibilities to generate thedemanded reactive power for the DFIG systemcontrolled bythe RSC or controlled by the GSCeach of them is analyzedin terms of the DFIG loss and the power converters loss.

REFERENCES

[1] Olimpo Anaya-Lara ―Wind Energy Generation: Modelling and Control 1st edition by John Wiley & Sons 2009.

[2] FatihBirol, ―Power to the People : The World Outlook for Electricity Investment International Energy Agency of the Organisation for EconomicCooperation and Development, http://www.iaea. org/Publications/Magazines/Bulletin/Bull461/power tothepeople3.html

[3] Andreas Petersson ―Analysis, Modeling and Control of Doubly-Fed Induction Generators for Wind Turbines Ph.D thesis Division of ElectricPower

Engineering ,Department of Energy and Environment Chalmers university of technology, G¨oteborg, Sweden 2005.

[4] Gabriele Michalke ―Variable Speed Wind Turbines -Modeling, Control, and Impact on Power Systems PhD thesis ,Department of RenewableEnergies at Darmstadt Technical University (Germany),2008

[5] SatishChoudhury ―Performance Analysis of Doubly-fed Induction Generator in Wind Energy Conversion System. A Thesis of Master ofTechnology in Electrical Engineering (Power Control & Drives, June National institute of technology rourkela 2011.

[6] A. D. Hansen and L.H.Hasen ―Market Penetration of Wind turbine concepts over the years, European Wind Energy, EWEA, vol. 10, pp. 81-97,2007[7] Requirements for Offshore Grid Connections, E. ON-Netz, Dusseldorf,Germany, Apr. 2008.

[8] M. Tsili and S. Papathanassiou, "A review of grid code technical requirements for wind farms," IET Renewable Power Gener., vol. 3, no. 3,pp. 308–332, Sep. 2009.

[9] A. Camacho, M. Castilla, J. Miret, R. Guzman, and A. Borrell, "Reactivepower control for distributed generation power plants to comply withvoltage limits during grid faults," IEEE Trans. Power Electron., vol. 29,no. 11, pp. 6224–6234, Nov. 2014.

[10] D. Zhou, F. Blaabjerg, M. Lau, and M. Tonnes, "Thermal behavioroptimization in multi-MW wind power converter by reactive powercirculation," IEEE Trans. Ind. Appl., vol. 50, no. 1, pp. 433–440,Jan. 2014.

[11] S. Muller, M. Deicke, and R. W. De Doncker, "Doubly fed inductiongenerator systems for wind turbines," IEEE Ind. Appl. Mag., vol. 8, no. 3,pp. 26–33, May 2002.

[12] A. Nagel and R. W. De Doncker, "Systematic design of EMI-filtersfor power converters," in Proc. Conf. Rec. Ind. Appl. Conf., 2000,pp. 2523–2525.

[13] R. Teodorescu, M. Liserre, and P. Rodriguez, Grid Converters for Photovoltaic and Wind Power Systems. Hoboken, NJ, USA: Wiley, 2011.

[14] R. Pena-Alzola, M. Liserre, F. Blaabjerg, R. Sebastian, J. Dannehl, andF. W. Fuchs, "Analysis of the passive damping losses in LCL-filterbased grid converters," IEEE Trans. Power Electron., vol. 28, no. 6,pp. 2642–2646, Jun. 2013.

[15] W. Wu, Y. He, T. Tang, and F. Blaabjerg, "A new design method forthe passive damped LCL and LLCL Filter-based single-phase grid-tiedinverter," IEEE Trans. Ind. Electron., vol. 60, no. 10, pp. 4339–4350,Oct. 2013.

[16] D. Zhou, F. Blaabjerg, M. Lau, and M. Tonnes, "Thermal cycling overviewof multi-megawatt two-level wind power converter at full grid code operation," IEEJ J. Ind. Appl., vol. 2, no. 4, pp. 173–182, Jul. 2013.

[17] S. Engelhardt, I. Erlich, C. Feltes, J. Kretschmann, and F. Shewarega,"Reactive power capability of wind turbines based on doubly fed inductiongenerators," IEEE Trans. Energy Convers., vol. 26, no. 1, pp. 364–372,Mar. 2011.

[18] R. Takahashi, H. Ichita, J. Tamura, M. Kimura, M. Ichinose, M. Futami,and K. Ide, "Efficiency calculation of wind turbine generation system withdoubly-fed induction generator," in Proc. Int. Conf. Electr. Mach., 2010,pp. 1–4.

[19] S. Wee, M. Shin, and D. Hyun, "Stator-flux-oriented control of inductionmotor considering iron loss," IEEE Trans. Ind. Electron., vol. 48, no. 3,pp. 602–608, Jun. 2001.

[20] A. G. Abo-Khalil, H. Park, and D. Lee, "Loss minimization control fordoubly-fed induction generators in variable speed wind turbines," in Proc.33rd Annu. Conf. Ind. Electron. Soc., 2007, pp. 1109–1114.

[21] C. Sintamarean, F. Blaabjerg, and H. Wang, "Comprehensive evaluationon efficiency and thermal loading of associated Si and SiC based PVinverter applications," in Proc. Annu. Conf. Ind. Electron. Soc., 2013,pp. 555–560.

[22] Wind Turbines—Part I: Design Requirements, 3rd ed., 2014, IEC 61400-1.

Authors:

R.Chander, Research Scholar from Department of Electrical Engineering in University College of Engineering (A), Osmania University, Hyderabad, Telangana, India.