"PERFORMANCE & ANALYSIS OF VARIABLE SPEED WIND TURBINES WITH DFIG USING IPC"

[1]KOMAL THAKUR
G. H. Raisoni College of Engineering and Management, Amravati, India
komalthakur558@gmail.com

[2]PROF. C. M. BOBADE
Assistant Professor, G. H. Raisoni College of Engineering and Management, Amravati, India
chetan.bobade@raisoni.net

ABSTRACT: *In the huge connected grid various types of renewable resources are added to extract more power. But due to this addition more number of problems occurs into the grid connection. The problems are voltage fluctuation and harmonic distortion. The very most important renewable source is wind generation system. The grid connected wind turbine produces power fluctuations which may produce flicker. Due to this connection it affects power quality. This paper presents various methodologies which minimized flicker which are produced due to variable speed of wind turbine. In this paper have to propose the novel approach for variable speed wind turbines with DFIG using IPC for flicker mitigation of grid-connected wind turbines and also show the performance analysis of the proposed system.*

Keywords: renewable resources, DFIG, IPC, wind turbines, voltage fluctuation, harmonic distortion

1. INTRODUCTION

During the last few decades, with the growing concerns about energy shortage and environmental pollution, great efforts have been taken around the world to implement renewable energy projects, especially wind power projects. With the increase of wind power penetration into the grid, the power quality becomes an important issue. One important aspect of power quality is flicker since it could become a limiting factor for integrating wind turbines into weak grids, and even into relatively strong grids if the wind power penetration levels are high. Flicker is defined as "an impression of unsteadiness of visual sensation induced by a light stimulus, whose luminance or spectral distribution fluctuates with time", which can cause consumer annoyance and complaint. Grid-connected variable speed wind turbines are fluctuating power sources during continuous operation. The power fluctuations caused by wind speed variation, wind shear, tower shadow, yaw errors, etc., lead to the voltage fluctuations in the network, which may produce flicker. The flicker emission with different types of wind turbines is quite different. Though variable-speed wind turbines have better performance with regard to the flicker emission than fixed-speed wind turbines, with the large increase of wind power penetration level, the flicker study on variable speed wind turbines becomes necessary and imperative. In this paper have to propose the novel approach for variable speed wind turbines with DFIG using IPC for flicker mitigation of grid-connected wind turbines and also show the performance analysis of the proposed system.

2. RELATED WORK

Yun-seong kim et. al. [1] has described the new control scheme, namely, a power factor scheme is suggested to mitigate flicker emission effectively. A wind turbine in a distribution system causes negative effects, such as voltage flicker. The flicker level is affected by wind speed, wind turbulence, grid conditions, and the type of generator. A new control scheme, namely, a power factor control scheme is suggested to mitigate flicker emission effectively. The proposed scheme controls the power factor angle to make the voltage deviation zero and, thus, to minimize the flicker level at the point of common coupling (PCC). It has been proven that this scheme is more effective in mitigating the flicker level of a DFIG compared to different mitigation schemes. A new control scheme using power factor angle control for flicker mitigation at the DFIG is suggested. The voltage deviation is controlled to zero value by changing the power factor angle of DFIG. The results of flicker mitigation by the power factor angle control are compared with those of other schemes.

Sharad W. Mohod et. al. [2] discussed that it is difficult to support the critical load without uninterrupted power supply. The proposed micro-wind energy conversion system with battery energy storage is used to exchange the controllable real and reactive power in the grid and to maintain the power quality norms as per International Electro-Technical Commission IEC- 61400-21 at the point of common coupling. The generated micro wind power can be extracted under varying wind speed and can be stored in the batteries at low power demand hours. In this scheme, inverter control is executed with hysteresis current control mode to achieve the faster dynamic switchover for the support of critical load. The combination of battery storage with micro-wind energy generation system, which will synthesize the output waveform by injecting or absorbing reactive power and enable the real power flow required by the load. The system reduces the burden on the conventional source and utilizes and battery storage power under critical load constraints. The system provides rapid response to support the critical loads. The scheme can also be operated as a stand-alone system in case of grid failure like an uninterrupted power supply.

S. W. Mohod & M. V. Aware [3] discussed that awareness of power quality is highly increased in a sensitive industry, where the standardization and performance is an important aspect. The connection of wind turbine to the grid affect's the electric grid power supply quality. Therefore it is necessary to maintain the power quality norm at the interface of the grid from the disruptive effect caused by wind turbine such as voltage fluctuation, switching operation, voltage dips, and reactive power & harmonics distortion on the grid. These disruptive effected can be minimized by adopting suitable control technique. Author proposed the control scheme for voltage source inverter (VSI) in a current control mode to inject the compensating current into the power system at point of common coupling. A hysteresis current controller has been implemented to generate the inverter switching signals using the reference from source voltage. This ensures that wind turbine system will inject current through inverter to maintain unity power factor. The wind turbine shall provide active and reactive power support to the load. Thus the power system will operate with stipulated power quality norm at point of common connection.

S. W. Mohod [8] describes simplified control strategy. The front-end voltage source inverter is operated in hysteresis current control mode. The reference signals are derived from one of the phase voltage. The main objective is the three phase supply currents both in its waveform, magnitude and phase to follow three phase reference signals. When this is achieved, ideally the supply current will then be always sinusoidal, with robust control over its magnitude and phase, irrespective of the harmonics and unbalance of the load demand or the supply voltage system. This confirms nearly unity power factor on supply side with active and reactive power support from the wind turbine side.

3. DFIG-BASED WIND TURBINE SYSTEM

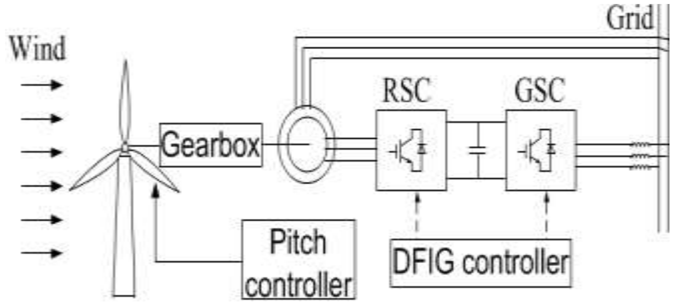


Figure 1: DFIG based wind turbine system

The DFIG based wind turbine system is shown in Figure 1. It consists of a wind turbine, gearbox, DFIG, a back-to-back converter which is composed of rotor side converter (RSC) and grid side converter (GSC) and a dc-link capacitor as energy storage placed between the two converters. In this scheme, turbulent wind is simulated by TurbSim [17]. Wind turbine code FAST is used to simulate the mechanical parts of wind turbine and the drive train. The controllers, DFIG, and power system are modelled by Simulink blocks. TurbSim and FAST are developed at the National Renewable Energy Laboratory (NREL) and they are accessible and free to the public. TurbSim is a stochastic, full-field, turbulent-wind simulator. It numerically simulates time series of three-dimensional wind velocity vectors at points in a vertical rectangular grid. TurbSim output can then be used as input into FAST. The open source code FAST can be used to model both two and three bladed, horizontal-axis wind turbines. It uses Blade Element Momentum (BEM) theory to calculate blade aerodynamic forces and uses an assumed approach to formulate the motion equations of the wind turbine [17].

IPC

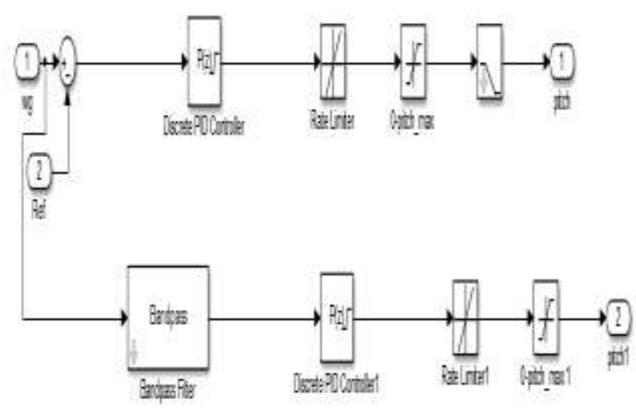


Figure 2: Pictorial view of IPC

The above figure shows the pictorial view of IPC. Normally, pitch control is used to limit the aerodynamic power captured from the wind. The PI controller used for adjusting the pitch angles works well in normal operation, however, the performance of the pitch control system will degrade when a rapid change in wind speed from low to high wind speed is applied to the turbine rotor. It takes a long time for a positive power error contribution to cancel the effects of the negative pitch angle contribution that has been built up from integration of these negative power errors

.SYSTEM MODEL

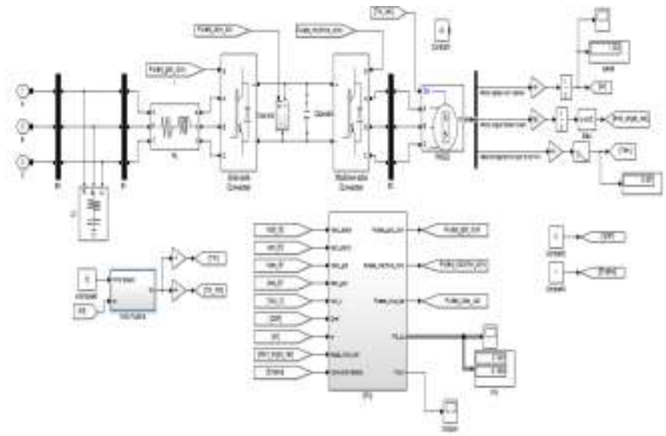


Figure 3: Overall scheme of IPC with DFIG

4. SYSTEM PARAMETERS

Description	Parameter	Real Value
Rated capacity	-	1.5Mw
Rated Voltage	V	575V
Rated frequency	F	50Hz
DC Capacitor Voltage	V	500V
Stator resistance	Rs	0.006 ohm
Armature inductance	L	0.000835 H
Snubber Resistance	Rs	10^5 ohm
Capacitance	C	10000 µF
Cut-off frequency	F	10 KHz
Damping Factor	Zeta	0.707
Carrier Frequency	F	2700Hz
Carrier Frequency	F	1620Hz

5. SIMULATION RESULTS FOR PROPOSED IPC SCHEME

The flicker mitigation using IPC is tested in many wind speed conditions. The variable speed wind turbine with DFIG and back-to-back converter are simulated with the proposed IPC method. The following figure illustrates the short-term and long-term view of the generator active power as well as the pitch angle in with and without IPC scheme. From these figures, it is shown that the active power to the grid is smoothed prominently. It is noted that when a power drop occurs which is caused by wind shear, tower shadow and wind speed variation, etc. , pitch angle will adjust, thus the generator active power will not drop so dramatically, in such a way that the power oscillation is limited in a much smaller range.

Case 1: At 12 m/sec wind speed

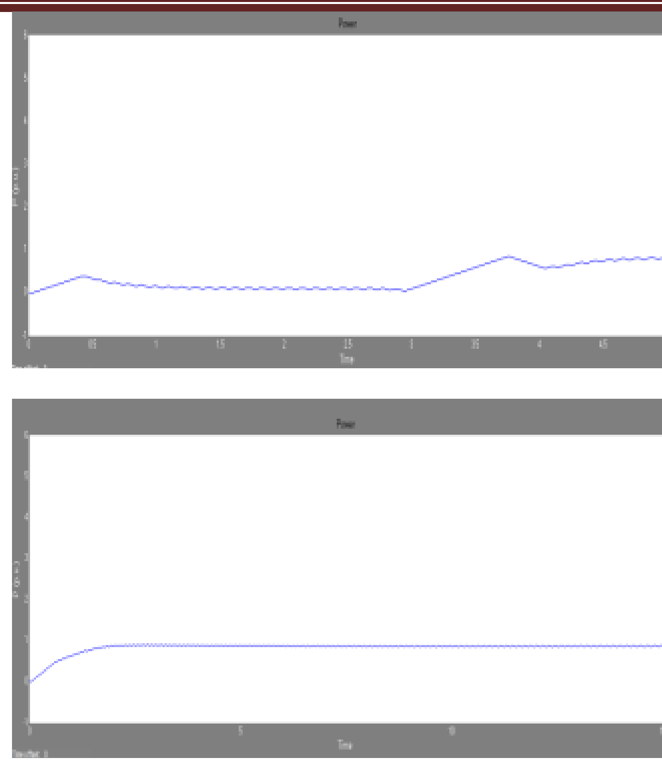
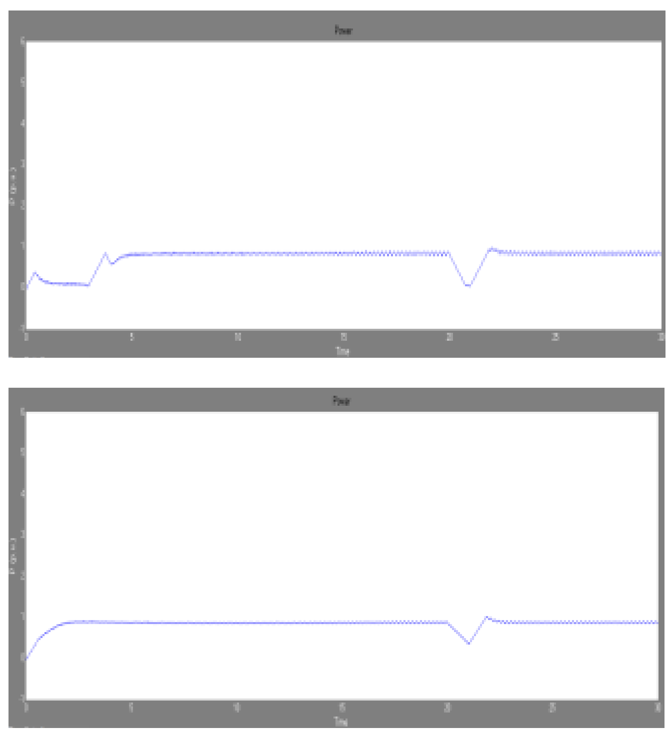


Figure 4: Short term view of active power without and with IPC



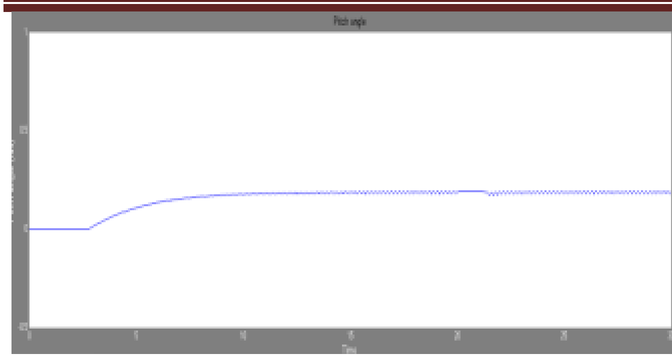


Figure 5: Long term view of active power without and with IPC and pitch angle

Case 2: At 13 m/sec wind speed

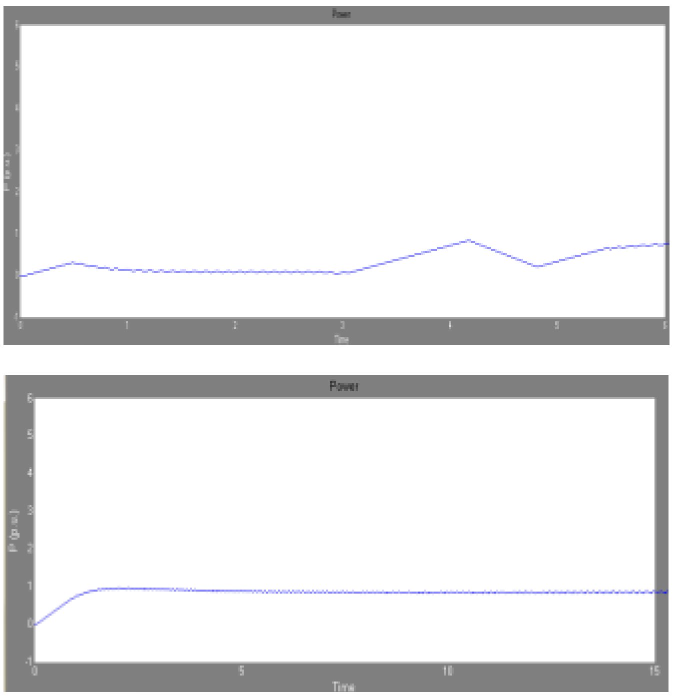
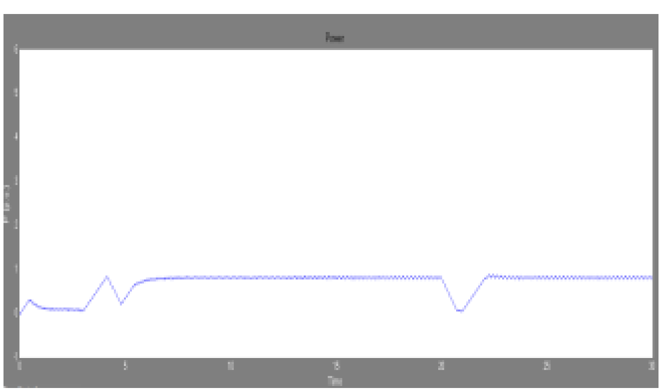
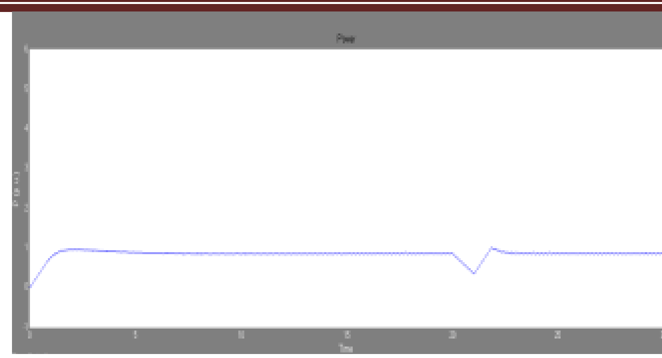


Figure 6: Short term view of active power without and with IPC





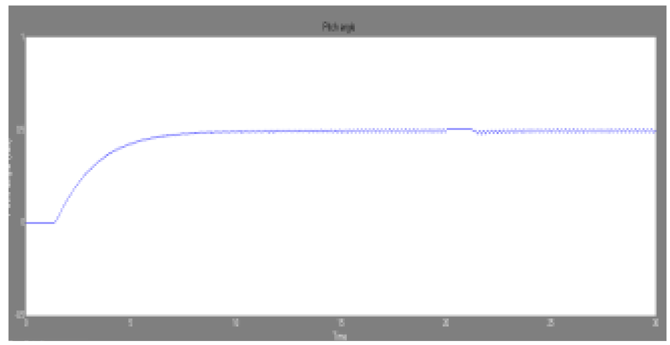


Figure 7: Long term view of active power without and with IPC and pitch angle

6. FUTURE SCOPE

There is an alternative flicker mitigation method which is the turbine rotor speed control taking advantage of the large rotor inertia. The newest measurement technologies such as LIDAC (Light Detection and Ranging) provide real-time information on wind condition and forecast for next few seconds. Based on this, it becomes possible to prevent peak loads by using IPC to develop preventive load. This measurement technique can be used to reduce fatigue loads. Advanced blade sensing systems provide information about load condition of rotor blade. These monitoring systems rely on sensor technology using e.g. optical fibres embedded in the rotor blade material. The micro wind energy generating system can also reduced the burden on conventional source and utilize the system under critical load constraints. The system can also be operated as a stand-alone system in case of grid failure like a uninterrupted power supply.

7. CONCLUSION

A novel topology called flicker mitigation of variable speed wind turbine with DFIG using IPC scheme is studied. Also various flicker mitigation technologies have been studied and discussed. Basically the method is selected as per its efficiency and reliability. All the methodologies are varies with its cost, complexity and performance. It has determined that IPC scheme is best choice among all the methods due to its capacity which leads to flicker emission prominently in both high and low wind speeds during continuous operation. The working principle, operating conditions are explained. The proposed methodology is explained. In methodology the detail theoretical aspects of each parts is explained. The simulation results at various conditions are observed and capability of the proposed topology to maintain the flicker level constant is checked. The operating efficiency differences between the two proposed models is calculated and shown by experimental results. Hence we can conclude that the proposed IPC topology have higher compensation ability and operating efficiency, which make it a unique solution for flicker.

8. REFERENCES

[1] Yun-Seong Kim and Dong-Jun Won, "Mitigation of the Flicker Level of a DFIG Using Power Factor Angle Control", IEEE Transaction on Power Delivery, vol. 24, no. 4, October 2009.

[2] S. W. Mohod and M. V. Aware, "Micro Wind Power Generator with Battery Energy Storage for Critical Load", IEEE Systems Journal, vol. 6, no. 1, march 2012.

[3] S. W. Mohod and M. V. Aware, "Power Quality Issues & It's Mitigation Technique in Wind Energy Generation", in Proc. IEEE ICQPH, September-October 2008.

[4] A. Larsson, "Flicker Emission of Wind Turbines during Continuous Operation", IEEE Transactions on Energy Conversion, vol. 17, no. 1, march 2002.

[5] Yunqian Zhang, Zhe Chen, Weihao Hu and Ming Cheng, "Flicker Mitigation by Individual Pitch Control of Variable Speed Wind Turbines With DFIG", IEEE Transaction on Energy Conversion, vol. 29, no. 1, march 2014.

[6] Tao Sun, Zhe Chen and Frede Blaabjerg, "Flicker Study on Variable Speed Wind Turbines with Doubly Fed Induction Generators", IEEE Transactions on Energy Conversion, vol. 20, no. 4, December 2005.

[7] S. W. Mohod & M. V. Aware, "Analysis and Design of a Grid Connected Wind Generating System with VSC", IEEE System Journal.

[8] S. W. Mohod & M. V. Aware, "Grid Power Quality with Variable Speed Wind Energy Conversion", proceeding of IEEE Int. Conf on Power Electronic Drives and Energy System (PEDES) Delhi, 5A-21, December 2006.

[9] S. W. Mohod and M. V. Aware, "A STATCOM-control scheme for grid connected wind energy system for power quality improvement", IEEE Syst. J., vol. 2, no. 3, pp. 346–352, Sep. 2010.

[10] K Sreelekha and P Sravankumar, "Flicker Mitigation by Individual Pitch Control of Fuzzy Logic Variable Speed Wind Turbines with DFIG", IJPRES, vol. 5, issue 2, July 2015.

[11] Viswanath Reddy.SN, Dr. Samalla Krishna and Ms. Katkuri Laxmi Chaitanya, "Flicker Mitigation and Voltage Quality Improvement in WP using IPC and ESS", IJR, vol. 2, issue 8, August 2015.

[12] L. Sirisaiah, J. Devender & P. Baburao, "Mitigation of Flickers in Variable Speed Wind Turbines by using Individual Pitch Control", IJSETR, vol. 4, issue 21, July 2015.

[13] Y. Sudheer & G. Mallamma, "Improve Flicker Mitigation on Wind Turbines by using Individual Pitch Control", IJATIR, vol. 7, issue 10, August 2015.

[14] B. Nirosha & C. Mohan Rao, "Individual Pitch Control of Variable Speed Wind Turbines with DFIG by flicker mitigation", IJMETMR, vol. 2, issue 7, July 2015.

[15] B. Rajanikanth & B. Srinu, "Flicker Mitigation for Variable Speed Wind Generating System", IJSER, vol. 3, issue 7, July 2015.

9. AUTHOR PROFILE

	**Miss. Komal Thakur** Completed Bachelor of Engineering in Electrical Engineering from G. H. Raisoni College of Engineering and Management Amravati, India. And currently pursuing Master of Engineering in Electrical Engineering from G. H. Raisoni College of Engineering and Management Amravati, India. Her research area is electrical power system, control system, signal and system, switch gear and protection.
	**Prof. Chetan M. Bobade** received the Bachelor of Engineering in Electrical (Electronics and power) Engineering and Master Degree in Electrical Power System from SSGMCE Shegaon. He is working as an assistant professor and Head of Electrical Engineering Department at G.H. Raisoni College of Engineering and Management Amravati, India. His research areas are Power System control, FACTS and power system stability improvement.