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Harmonics Reduction in Doubly Fed Induction Generator Using Unified Power Flow Controller

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Abstract *—This paper present a control of harmonics by using of Unified Power Flow Controller (UPFC).and also control of total harmonics distortion (THD) in the wind based energy system due to the fluctuation in wind power and the stability problem and also controlling of DFIG in the power plant. Unified Power Flow Controller (UPFC) is used to control the power flow in the transmission system and also to control phase angle, line impedance and voltage magnitude. The main scope of this paper involves simulation of DFIG based wind energy conversion system with UPFC using MATLAB/SIMULINK.*

Keywords*-Doubly Fed Induction Generator (DFIG), UPFC, THD, Harmonics, STATCOM, SSSC*

I. INTRODUCTION

Today harmonics is the major problem where the large amount of electricity is produced. So it is necessary to control of harmonics to reduce the negative impact of the power system. The main aim of the elimination of harmonics is to improve the power quality of the system. And also to reduce line losses, over current, distortion in voltage and current wave form and equipment damages. At present years wind power generation has experienced a very fast development in the whole world. As the wind energy power penetration into the grid is increasing quickly, the influence of wind turbines on power quality is becoming an important issue. Flicker is induced by voltage fluctuations, which are caused by load flow changes in the grid. Grid connected wind turbines may have considerable fluctuations in output power, which depend on the wind power generation technology applied [1].The ability to control power flow in an electrical power system without generation rescheduling or topology changes can improve performance using the power system performance using controllable components.

The most commonly used devices for flicker mitigation is the STATCOM and SSSC. However, UPFC has received much attention recently. Compare with STATCOM and SSSC, UPFC as overall superior functional characteristics, better performance, faster response and capable of providing both active and reactive power. UPFC is a combination of separate shunt and series elements. That means combination of STATCOM and SSSC. So the it has combine features of STATCOM and SSSC[2]. STATCOM is a shunt controller it inject current into the system at the point of combination. As long as the injected current is in phase with the line voltage, the shunt controller only supplies or consumes variable reactive power. Any other phase relationship will involve handling of real power as well [2] [3].

Flexible ac transmission system (FACTS) technology is the ultimate tool for getting the most out of existing equipment via faster control action and new capabilities. The most striking feature is the ability to directly control transmission line flows by structurally changing parameter of the grid and to implement high gain type controller based on fast switching. The application of FACTS devices to power system security has been an attractive ongoing area of research. In most of the reported studies attention has been focused on the ability of these devices to improve the power system security by damping system oscillation and minimal attempts have been made to investigate the effect of these devices on power system reality. By using of UPFC it can control phase angle, line Impedance, and voltage magnitude and also as well reduced the harmonics to improve power quality of the system.

II. HARMONICS

Harmonics is basically nothing but the distortion in voltage and current wave forms. Due to current distortion voltage distortion occurred on wave forms. Harmonics is basically sinusoidal component having a frequency that is the multiple of the fundamental frequency means if your fundamental frequency is 50 Hz or 60 Hz for some other country region we know that even and odd both harmonics are present in to the system if the 3^{rd} harmonics are present into the system then the 3^{rd} harmonics frequency will be 3f means 3*50 = 150 Hz is flowing and that will be the make the negative impact of the system.so that harmonics must have to be reduced as much as possible. There are two types of the harmonics one is current harmonics and other one is voltage harmonics and which distorted voltage and current respectively. And this harmonics are occurred in the nonlinear load because it does not varies the current with the same frequency.it can be control of the harmonics using IEEE standard 519-1992.due to harmonics it affects the wind turbine generator Due to harmonics following problem occurs.

- Poor power factor
- High system losses

- Overheating of generator
- Power electronics protective devices malfunction
- Increase vibration of the generator
- Equipment damages

III. CONTROL SCHEME OF WIND TURBINE

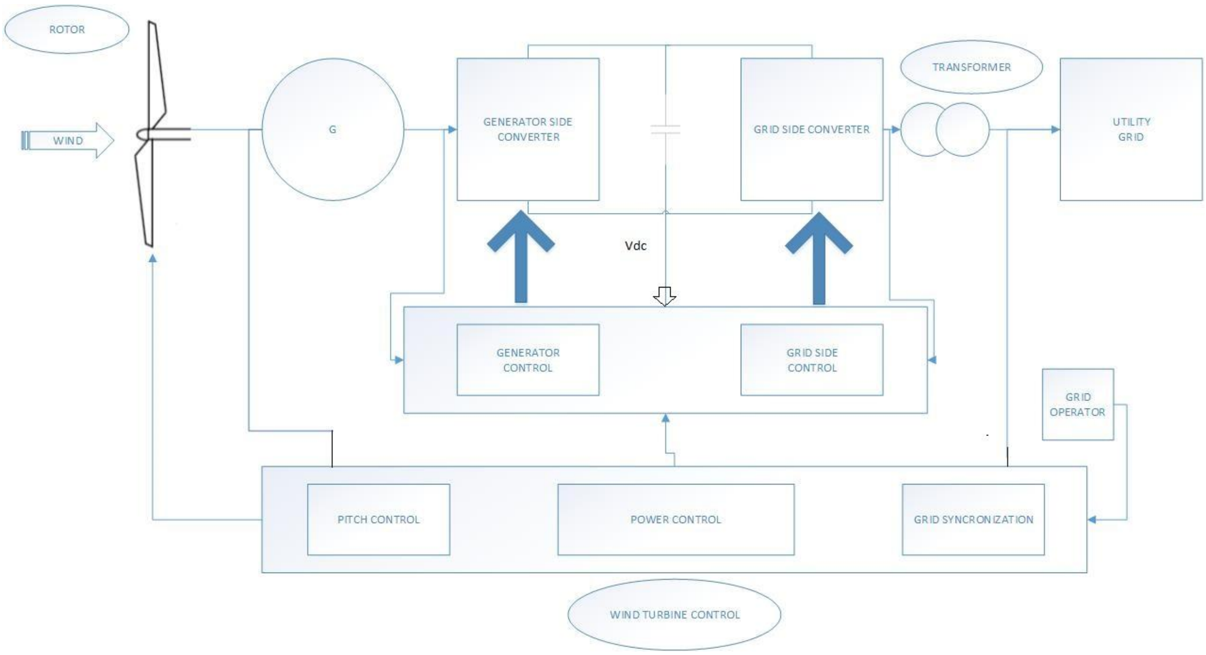

Figure 1 Arrangement of WT

The control block diagrams for the chosen Wind turbine topology, are presented in Figure. For variable speed operation, the WT uses a full scale back-to-back converter. The generator side converter is controlling the speed of the generator for maximum power extraction. The grid side converter controls the voltage on the DC-link and also the reactive power flow between the WT and grid. Another control for the WT is the pitch control. It is applied to the rotor blades and modifies the angle of attack of the blades so that the output power can be controlled during high wind speeds.

IV. MATLAB/SIMULATION WITH RESULTS

The schematic arrangement of unified power flow controller is shown. The UPFC consists of two voltage source converters; series and shunt converter, which are connected to each other with a common dc link. Series converter or Static Synchronous Series Compensator (SSSC) [4] is used to add controlled voltage magnitude and phase angle in series with the line, while shunt converter or Static Synchronous Compensator (STATCOM) is used to provide reactive power to the ac system, besides that, it will provide the dc power required for both inverter. Each of the branches consists of a transformer and power electronic converter. These two voltage source converters shared a common dc capacitor. When the SW1 and SW2 are open at that time both the converter are act as a STATCOM and SSSC controlling the line reactive current and reactive voltage injected in the shunt and series respectively in the line. And when The closing of the switches 1 and 2 enables the two converters to exchange real (active) power flow between the two converters The active power can be either absorbed or supplied by the series connected converter The shunt connected converter not only provides the necessary power required, but also the reactive current injected at the converter bus. A Unified Power Flow Controller (UPFC) is used to control the power flow in a 120 kV /25 kV transmission systems. The system connected in a loop configuration consists essentially of three buses (B575, B25, B120) interconnected through transmission line (L1) and two transformer banks. The model of DFIG based 10MW wind farm with UPFC is designed using MATLAB/ SIMULINK is shown in Figure.

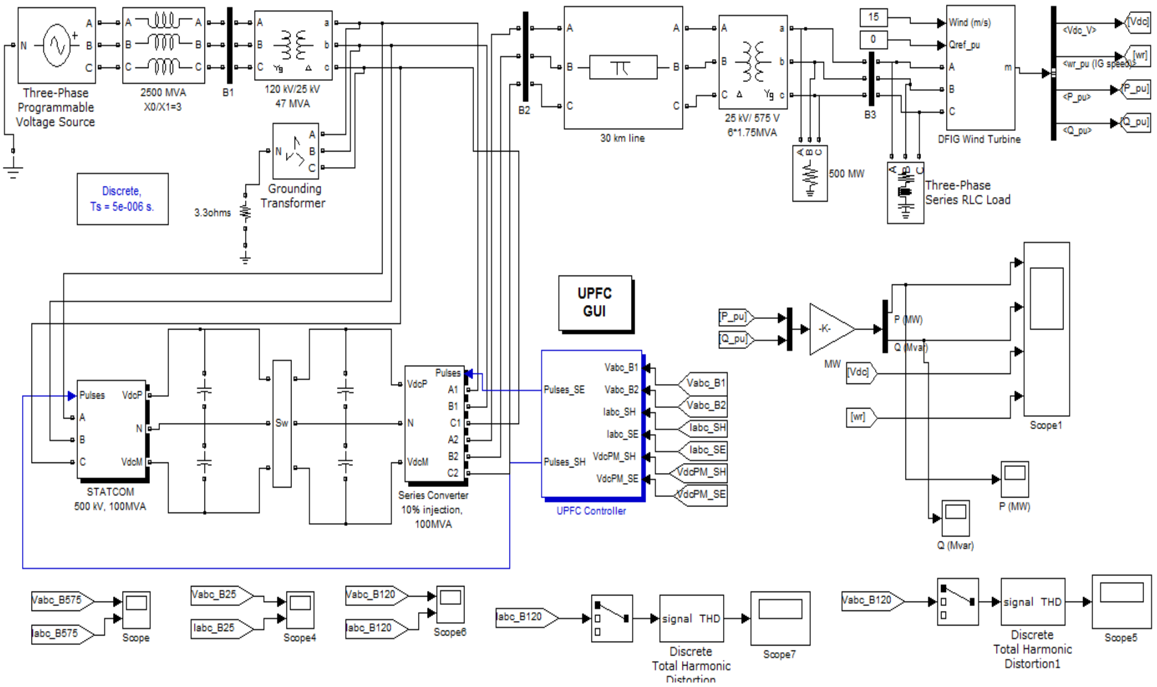

Figure 2 Simulation of power quality improvement in DFIG with using UPSC

V. CHARACTERISTICS OF UPFC

Line outage, congestion, cascading line tripping, power system stability loss are the major issues where capability and utilization of FACTS are noticed. Representative of the last generation of FACTS devices [2] is the Unified Power Flow Controller (UPFC). The UPFC is a device which can control simultaneously all three parameters of line power flow (line impedance, voltage and phase angle). Such "new" FACTS device combines together the features of two "old" FACTS devices: the Static Synchronous Compensator (STATCOM) [5] and the Static Synchronous Series Compensator (SSSC).

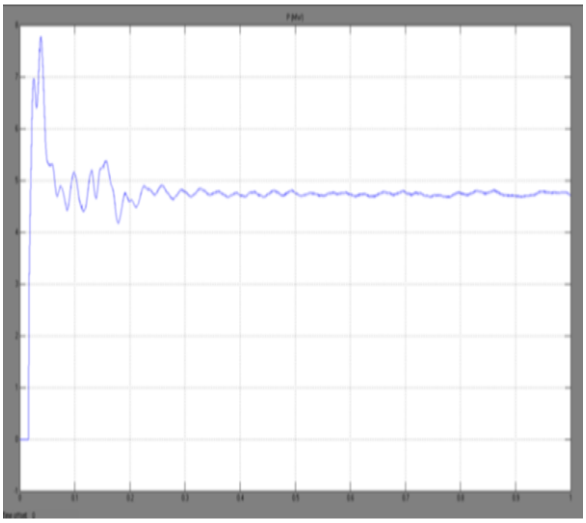

Figure 3 Wind turbine output active power

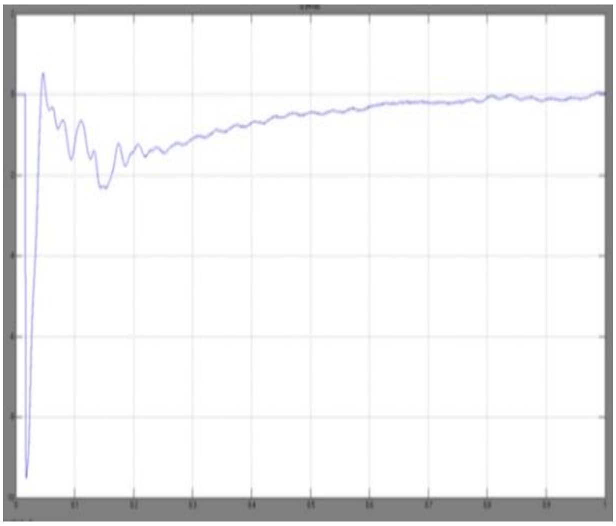

Figure 4 Wind turbine output reactive power

When the two converters are operated in UPFC [6] mode, the shunt converter operates as a STATCOM. It controls the bus B120 voltage by controlling the absorbed or generated reactive power while also allowing active power transfer to the series converter through the DC bus. The reactive power variation is obtained by varying the DC bus voltage. The DC link voltage is shown in Fig.5. The rotor speed is shown in Fig.6

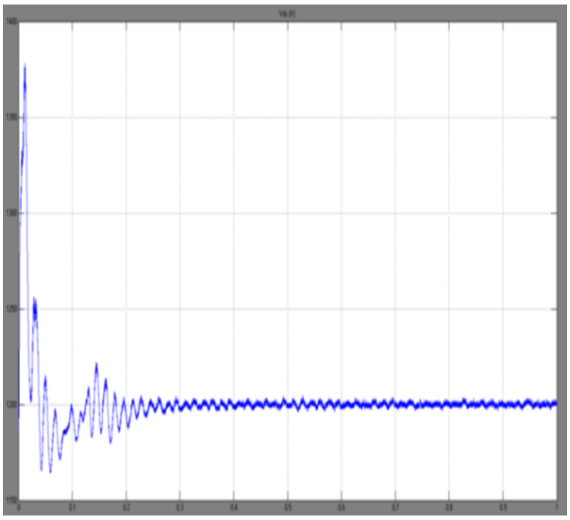

Figure 5 Dc link voltage

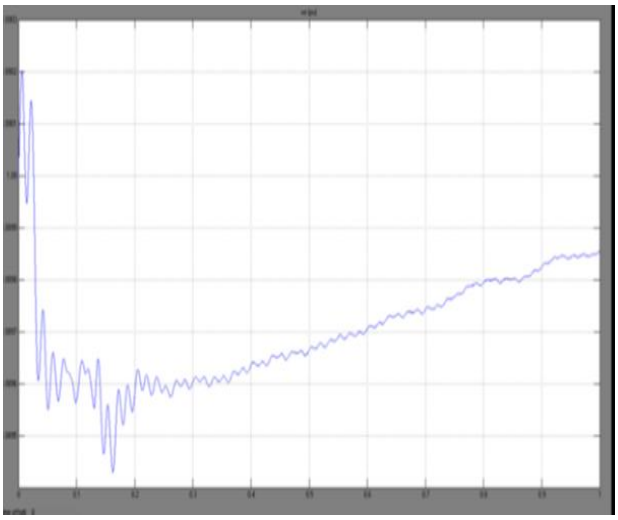

Figure 6 Rotor speed

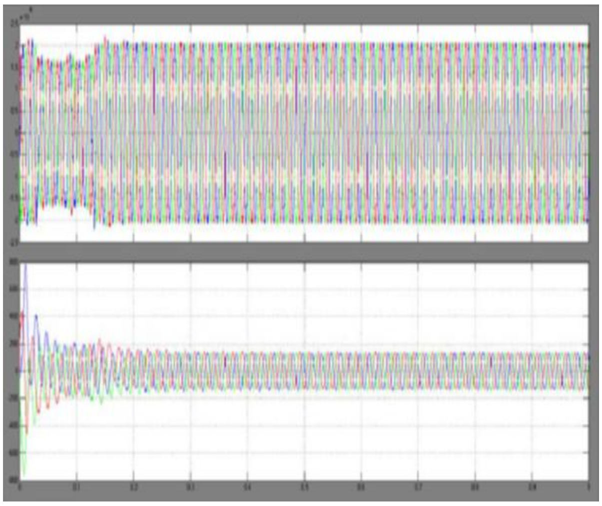

Fig 7 The voltage, current at bus B25 with UPFC

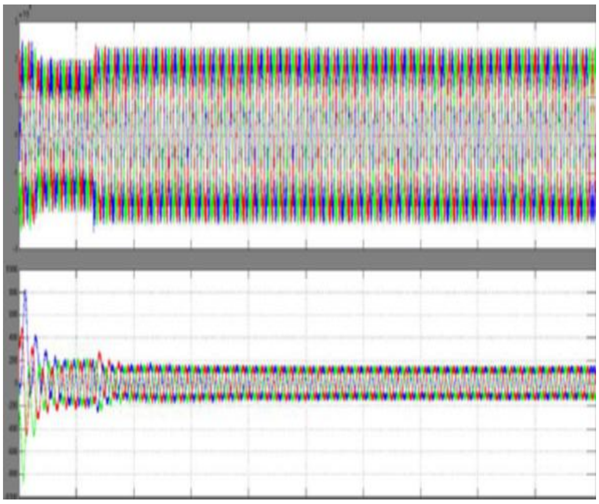

Fig 8 The voltage, current at bus B25 without UPFC

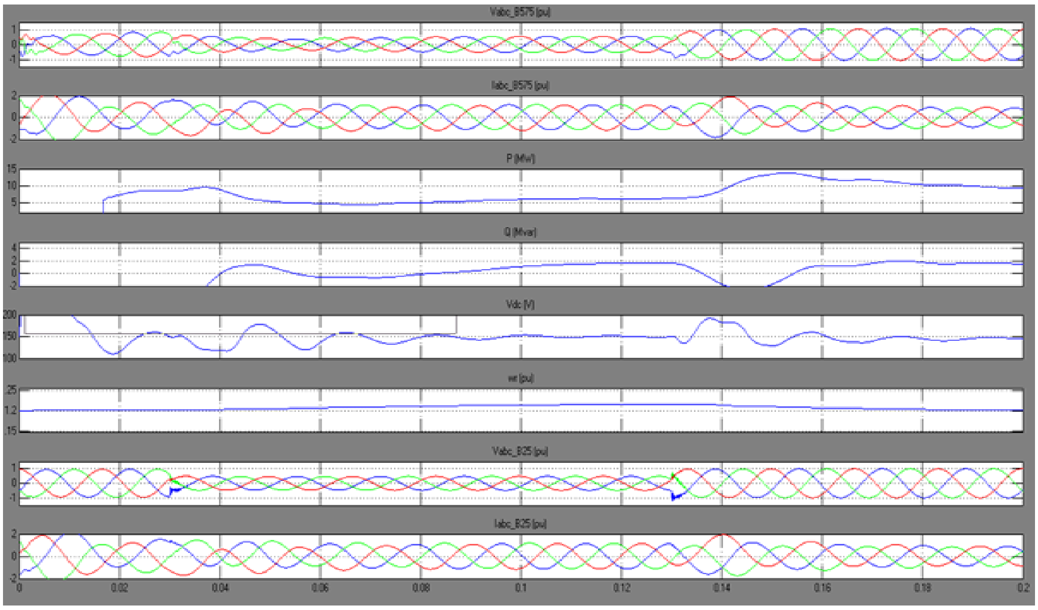

Figure 9 Waveforms For Without Connection of UPFC

TABLE I: THD OF V & I WITHOUT AND WITH UPFC

	% THD in FFT Analysis		THD in Discrete Total Harmonic Distortion block	
	Without UPFC	With UPFC	Without UPFC	With UPFC
Vabc_B575	31.76	3.09	0.3176	0.03012
Iabc_B575	14.02	1.69	0.1276	0.01721
Vabc_B25	12.03	1.76	0.1152	0.01863
Iabc_B25	14.89	1.80	0.1358	0.02234
Vabc_B120	1.21	0.08	0.01243	0.000876
Iabc_B120	15.20	1.82	0.1479	0.02245

VI. CONCLUSION

In this work, power quality issues like harmonics are analyzed with respect to wind power generator connected to grid. The simulation techniques of a wind power generating system connected to grid had been analyzed by using MATLAB/SIMULATION. In power system transmission it is desirable to maintain the voltage magnitude, phase angle and line impedance. Therefore, to control the power from one end to another end, this concept of power flow control and voltage injection is applied. The UPFC has combine feature of Static Synchronous Compensator (STATCOM) and the Static Synchronous Series Compensator (SSSC). In practice, these two devices are two voltage source inverters (VSI's) connected respectively in shunt with the transmission line through a shunt transformer and in series with the transmission line through a series transformer, connected to each other by a common dc link including a storage capacitor.

The shunt inverter is used for voltage regulation at the point of connection injecting an opportune reactive power flow into the line and to balance the real power flow exchanged between the series inverter and the transmission line. The series inverter can be used to control the real and reactive line power flow inserting an opportune voltage with controllable magnitude and phase in series with the transmission line. It was found that the UPFC [7] regulates the voltage of the bus as well as regulates the active and reactive power of the buses and the lines within specified limits. Therefore the UPFC can fulfill functions of reactive shunt compensation, active and reactive series compensation and phase shifting. The UPFC controller mitigates the harmonic distortion that caused by the nonlinear load where all values of THD for voltage and current at all AC buses are decreased to values within allowable limits of IEEE standard.

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