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Original Article

Improvement of Power Quality of a Grid Connected Wind Energy System Using D-STATCOM

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Abstract *- It is the study of improving power quality in which wind energy is connected to electrical energy through a distributed D-STATCOM, which is connected to the grid. This study consists of a wind turbine connected to a doubly-fed induction generator, voltage sourced inverter which is connected to the utility through the point of common coupling. As the study deals with the multifunctional feature,s a direct power control is proposed. This direct power also reduces harmonics before connecting to utility and also reduces reactive power. Moreover, this system ensures the efficiency of the system. The control algorithm is proposed in this study is very much effective in injecting active power into the system, thereby reduces harmonic currents and compensating for reactive power.*

Keywords - *DFIG, D-STATCOM, PI Controller, Direct Power Control Method.*

I. INTRODUCTION

There are several advantages of non-conventional generation of electricity compared to conventional mode. Non-conventional is eco-friendly, harmless, long-lasting. Non-conventional generation of electricity is produced through sunlight, tides, oceanic currents, geothermal, wind, etc., in which the energy produced by wind is more feasible, cost-effective, used for several applications(2). The wind energy conversion system has many components. Which most important component is the generator used in this conversion system. Permanent magnet Synchronous generator primarily has many advantages compared to Self-Excited Synchronous generator and doubly-fed induction generator. Many devices that were used for domestic and industrial purposes have non-linear behavior; they cause non-sinusoidal currents which exhibit high harmonic content. This decreases the system efficiency as the power factor gets reduced, increases losses. Generally, by using a passive LC Circuit, current harmonics get reduced, and the power factor can be increased(5).

Due to the enhancement of the Power Electronics technology, there is more research taking place on active filters.

In which Shunt Active Power Filter is one of the active filters which injects the current equal and opposite to harmonic components so there will be an only fundamental component at the point of common coupling(5).

In this study, the power is injected into the utility grid through the Doubly fed induction Generator coupled with a wind turbine and Shunt Active filter. This conversion system can provide reactive power compensation, power factor correction, inject active power the provided load. For harmonic currents detection, many researchers used the p-q theory, and their elimination is based on current control loops(3).

In this study, Direct Power Control is used, which provides multi-functionality of the inverter which is connected to the grid and also acts as an interface for wind energy conversion system. This Direct Power Control provides switching moments of inverter switches through the amplitude control of instantaneous reactive and active power. DC power voltage controller is the block that provides a command for active power control. Reactive power control command comes from outside the dc power voltage controller block.

In this work, hysteresis comparators are used, which compare the error between the estimated feedback control input and commands. The main advantage of Direct Power Control is that PWM and inner current loops are not required. In this work, a switching table is used, which is based on instantaneous errors between the instantaneous values and commands. This helps to eliminate the PWM and inner current loops. This work is done in MATLAB Simulink model simultaneous results are used to validate the correctness of control system which is designed(4).

II. SYSTEM CONFIGURATION

The system consists of Shunt active filter connected to a Wind energy conversion system. This system consists of

a Doubly fed induction Generator connected to a three-phase inverter through the rectifier converter. This 3 phase inverter is connected to the grid through filter and load.

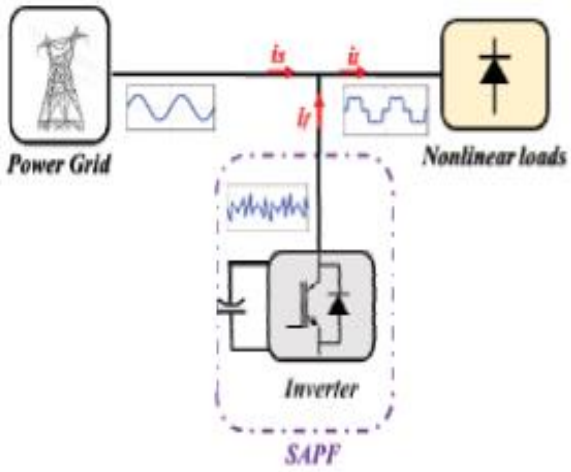

Fig. 1 Representation of grid &load connected to DSTATCOM

In this study, the inverter not only transfers the power from the wind turbine but also promoted compensation or elimination of harmonic currents and reactive power.

The use of wind turbines is to convert wind energy to mechanical energy. The gearbox is used to connect shafts of wind turbine and doubly-fed induction generator. The inclusion of the gear box is to provide rotational torque to the generator. The generator develops 3 phase voltage and current, which is fed to 3 phase converter.

Shunt active filter consists of 2 parts control part and power. The use of the control part is to control the switching instants of semiconductor elements, and the power part consists of an energy source, inverter, and coupling filter.

A. DPC

The DPC is developed in 1998, which is similar to the direct torque control of induction machines. In this, the magnitude of active and reactive power instantaneous values are controlled. Because of this voltage sensor is not used in 3 phase inverter.

$$i_s = i_l + i_f \quad (1)$$

i_s: current of source.; i_l : current of the load; i_f : current compensation.

$$S_s = P_S + jQ_S \quad (2)$$

$$P_S = v_{sa}.i_{sa} + v_{sb}.i_{sb} + v_{sc}.i_{sc} \quad (3)$$

$$Q_S = \frac{1}{\sqrt{3}}\left[(v_{sb} - v_{sc}).i_{sa} + (v_{sc} - v_{sa}).i_{sb} + (v_{sa} - v_{sb}).i_{sc}\right] \quad (4)$$

B. Determination Factor

The digitalized signal is obtained from a power source voltage vector. In order to obtain this working plane is divided into 12 sectors.

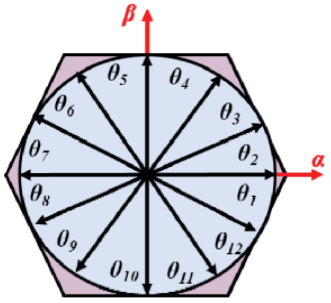

Fig. 2 Representation of determination factor

The sectors determined by the following Eq.(a, b).[5].

$$(N - 2)\frac{\Pi}{6} < \theta_N < (N - 1)\frac{\Pi}{6} \quad (a)$$

Where N= 1, 2, 3….12 is the number of the sector.

$$\theta = Arctg\left[\frac{V_\beta}{V_\alpha}\right] (b)$$

PI Controller:

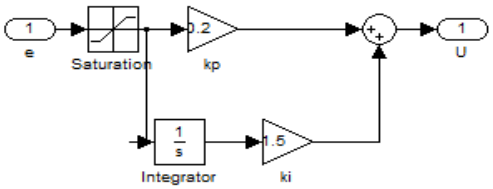

Fig. 3 PI controller Representation

It regulates the continuous function of the voltage inverter. The input to this is a reference voltage and capacitor voltage. And the output of PI Controller the active power pref.

$$G_{V_{dc}(PI)}(s) = \frac{k_p + s.k_i}{k.s^2 + k_p.s + k_i} \quad (5)$$

This transfer function represents a second-order system.

III. RESULTS AND DISCUSSION

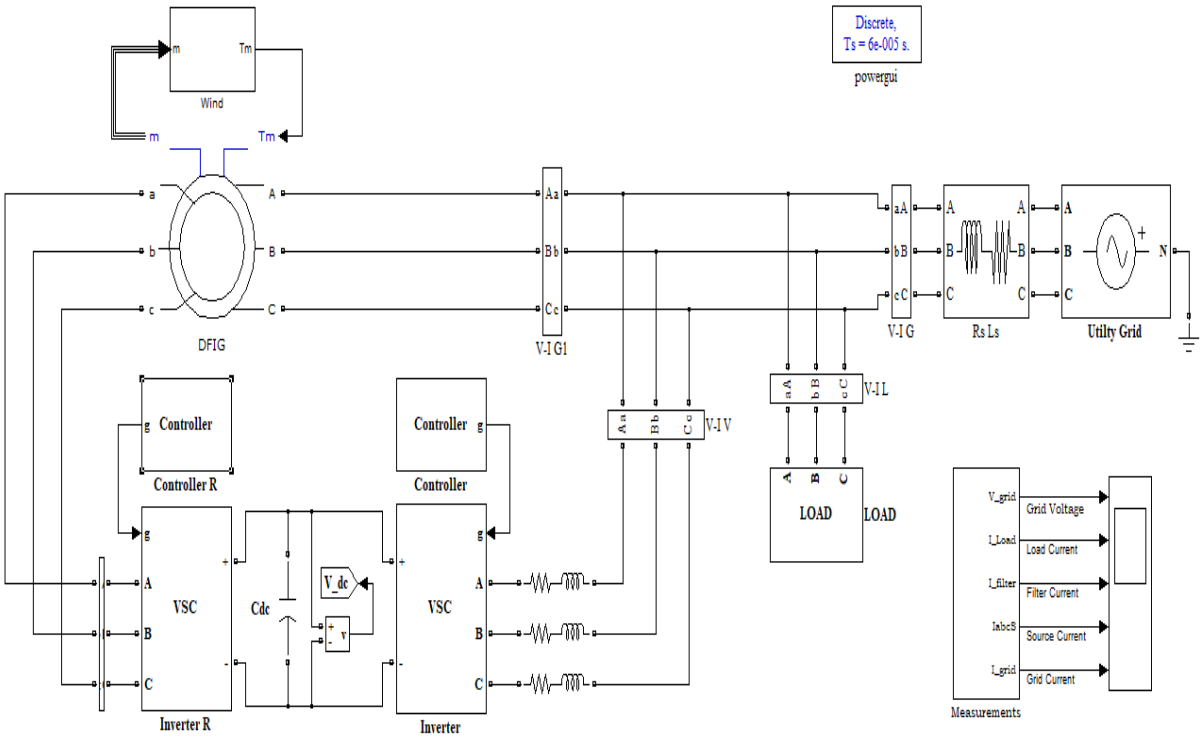

Fig. 4 Schematic representation of grid-connected to wind energy system using DSTATCOM

OUT PUT waveforms:

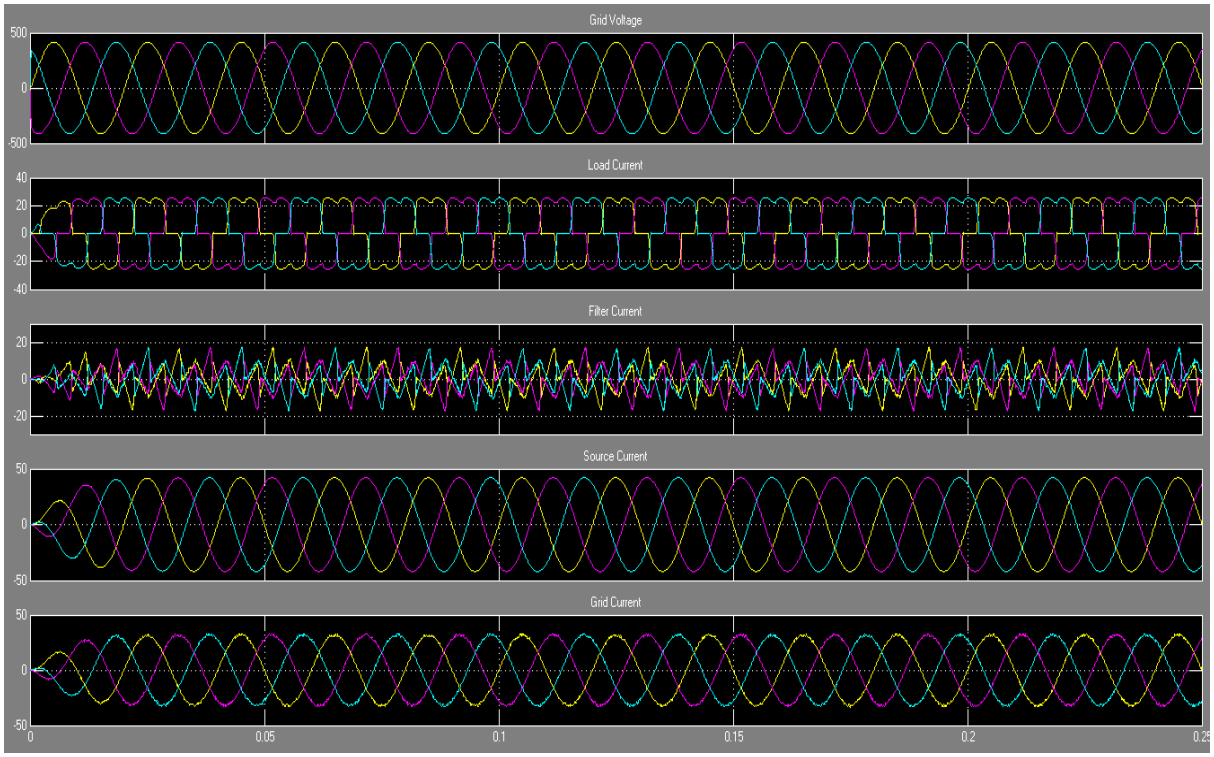

Table 1. Parameters

Wind turbine parameters	
Nominal power	4000w
Base wind speed	12 m/s
Base rotational speed	1pu
Pitch angle	0°
Grid power	
Source Voltage Vs	415v
Supply frequency Fs	50 Hz
Source impedance R_s, L_s	0.03ohms, 0.15e-3H
SAPF	
Filter impedance R_f, L_f	0.064ohms, 2.033e-6H
DC-link voltage reference V_{dc} ref	700v
DC-link capatitor C	600e-6F

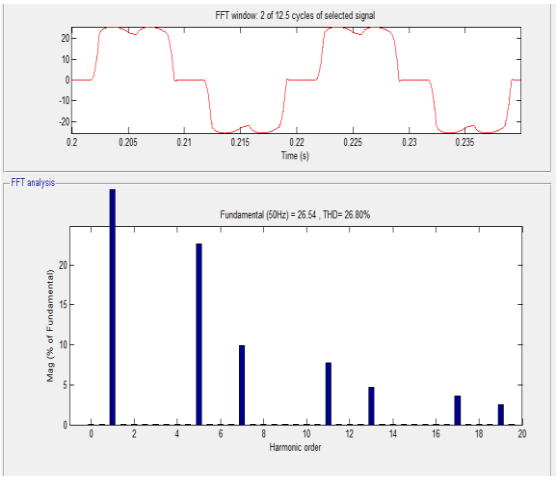

Fig. 5 THD before placing the controller

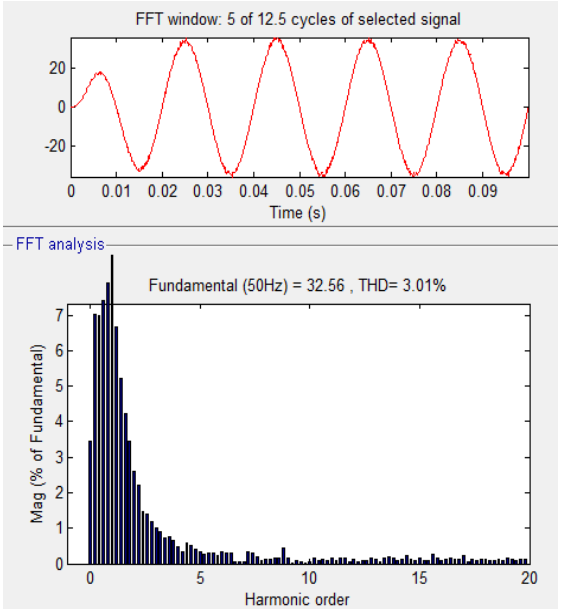

Fig. 6 THD after placing the controller

IV. RESULTS ANALYSIS

From the above represented total harmonic distortion fig5 and fig6, we can conclude that by implementing the Distributed Statcom in the system, harmonic content will be reduced by this method. The schematic diagram fig4 will represent the total simulation model of the grid-connected wind energy system, which is connected to the grid by DSTATCOM.

Initially, to analyze the results, rotatory angles of 120^0 phase shift has bought into the stationary phase shift of $90^0$by a new technique called as Parks transformation technique which is connected to the switching table by using direct power control method total harmonic distortion(THD) was improved in the system.

V. CONCLUSION

This paper completely deals with the improvement of power quality of a system with the implementation of distributed statcom. A part of that, a new technique was implemented to improve the power quality of a system by using the Doubly-Fed induction generator(DFIG).

Finally, by maintaining the grid and load parameters along with wind operation, total harmonic distortion (THD) has been improving in the current profile of the hole system.

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