REDUCTION OF SOURCE CURRENT HARMONICS USING GRID CONNCECTED INVERTER INTERFACED BY WIND ENERGY CONVERSION SYSTEM

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ABSTRACT

This paper deals with a three-phase multifunctional grid-connected inverter interfaced with a wind energy conversion system (WECS) is described. The studied system consists of a permanent magnet synchronous generator (PMSG) based wind turbine, a rectifier and a three-phase voltage source inverter connected to the utility at the point of common coupling. To ensure the multifunctional feature, we propose a direct power control (DPC) which is applied to eliminate line current harmonics, compensate reactive power and feeding wind power into the utility. Simulation results are provided to demonstrate the effectiveness of the proposed system. The results show that the control algorithm of system is effective for eliminating harmonic currents, reactive power compensation and inject the active power available from the PMSG wind turbine into the load and/or grid, which allowed us to confirm the robustness of the proposed strategy.

I.INTRODUCTION

Non-conventional mode of generation of electricity has several advantages over conventional sources of generation. It is ecofriendly, cost effective, damage free, long lasting and more over harmless [1]. Electricity generation through wind energy is considered as socially beneficial and economically feasible for several applications [2]. In a year many large utility scale wind power plants are installed. There are different components of a Wind Energy Conversion System (WECS), of which the most important is the type of generator used. There are several types of generators used such as doubly fed Induction generator (DFIG), Self-excited induction generator (SEIG), and permanent magnet synchronous generator (PMSG). Among these generators, PMSG has several advantages, which make it very usable for WECS. Domestic and industrial devices use more and more circuits having a nonlinear behavior. They create, in the distribution networks, non-sinusoidal currents causing high harmonic currents [3]. This result in the reduction of power factor, reduces the efficiency and reduces the system performs. Traditionally, the simplest method to eliminate current harmonics and to increase the power factor is the usage of passive LC. However, the use of passive filter has many disadvantages [4,5]. Recently, because of the rapid progress in modern power electronic technology, the previous works were oriented mostly on the active filters instead of passive filters. The shunt active power filter (SAPF) is one of the most popular active filters.

The shunt active power filter injects currents equal but opposite with the harmonic components, thus only the fundamental components flows in the point of common coupling (PCC). In this paper, a PMSG wind turbine coupled with shunt active power filter in order to inject the wind power into the utility grid. The whole system can provide the power factor correction, harmonic elimination, reactive power compensation, and simultaneously inject the active power available from the PMSG wind turbine into the load and/or grid. Many researches have been done on active power filter supplied by wind energy conversion System. And a many of them they used ‘‘p–q theory’’ for harmonic currents detection and elimination which is based on harmonic currents identification and instantaneous current control loops.

II.EXISTING SYSTEMS:

Domestic and industrial devices use more and more circuits having a non-linear behavior. They create, in the distribution networks, non-sinusoidal currents causing high harmonic currents [3]. This result in the reduction of power factor, reduces the efficiency and reduces the system performs. Traditionally, the simplest method to eliminate current harmonics and to increase the power factor is the usage of passive LC. However, the use of passive filter has many disadvantages [4,5]. Recently, because of the rapid progress in modern power electronic technology, the previous works were oriented mostly on the active filters instead of passive filters. The shunt active power filter (SAPF) is one of the most popular active filters.

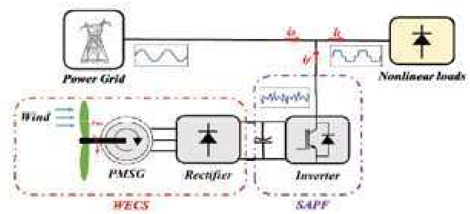


Fig 1:WECS with SAPF

The shunt active power filter injects currents equal but opposite with the harmonic components, thus only the fundamental components flows in the point of common coupling (PCC). In this paper, a PMSG wind turbine coupled with shunt active power filter in order to inject the wind power into the utility grid. The whole system can provide the power factor correction, harmonic elimination, reactive power compensation, and simultaneously inject the active power available from the PMSG wind turbine into the load and/or grid.

III.PROPOSED SYSTEM:

This paper proposes the direct power control (DPC) technique for a multifunctional grid-connected inverter interfaced with a wind energy conversion system (WECS). The main purpose of DPC is to control the amplitude of the instantaneous active and reactive powers to generate the switching moments of the inverter switches [8]. The active power command is provided from a dc-bus voltage controller block, while the reactive power command is directly given from the outside of the controller. Errors between the commands and the estimated feedback power are input to the hysteresis comparators. Inner current control loops and PWM modulator are not required in DPC because the converter switching states are selected by a switching table based on the instantaneous errors between the commanded and estimated values of active and reactive powers [9]. The overall control system of a multifunctional grid connected inverter interfaced with a wind energy conversion system is built in the Matlab/Simulink environment. Then, the simulations results are provided to validate the correctness of the adopted control system.

The structure of shunt active power filter interfaced by Wind Energy Conversion System (WECS) is shown in Fig. 1. It consists of a permanent magnet synchronous generator (PMSG) based wind turbine connected through a rectifier converter to a three-phase inverter that is connected to a grid through a simple filter and nonlinear load. Whereas the inverter is used to transfer the power from wind turbine, it also assure the compensation of the harmonic currents and reactive power.

Wind energy conversion system is consisting of a wind turbine which converts wind energy to mechanical energy. The shaft of the wind turbine is connected to the shaft of the Permanent magnet synchronous generator through a gear box. The gear box provides the rated torque to the generator. The generator develops rated three phase voltages and currents, which are then connected to three-phase converter.

A.DIRECT POWER CONTROL:

The main idea of the direct power control (DPC) originally proposed by Ohnishi (1991) and further developed by Noguchi and Takahachi in 1998, is similar to the direct torque control (DTC) of induction machines. Instead of flux and torque, the active power (P), and reactive power (q) are selected as two instantaneous magnitudes to control [5,10]. The figure .4 shows the configuration of the direct power control without voltage sensor for a three phase inverter interfaced with a wind energy conversion system. The estimated values of (ps) and (qs) in terms of the three phase line currents and voltages can be derived as

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

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

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

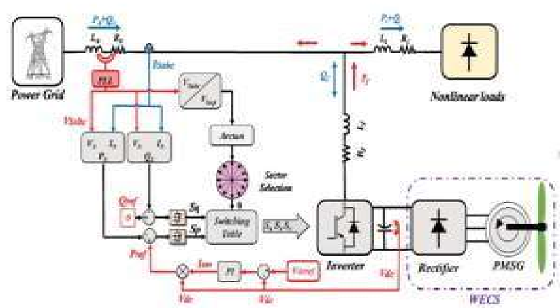
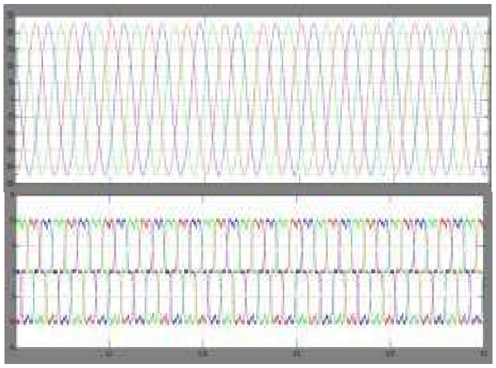


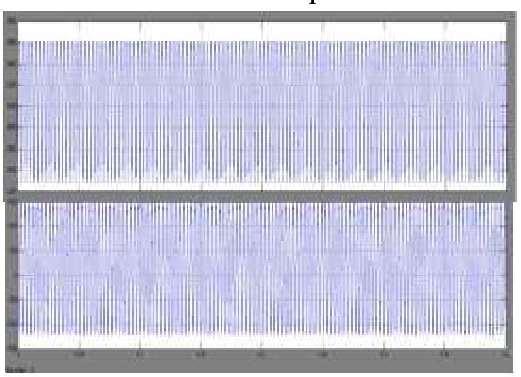
Fig. 2. DPC control of Shunt Active Power Filter Interfaced by Wind Energy Conversion System.

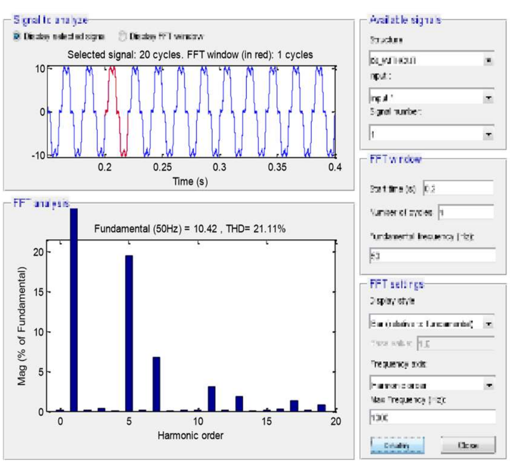
IV.SIMULATION RESULTS

Simulations of a multifunctional gridconnected inverter interfaced with a wind energy conversion system (WECS) controlled by proposed direct power control have been carried out with Matlab/ SimulinkTM software. The system is not only capable of supplying extracted wind power to the power system, but it also can significantly mitigate harmonic currents which are drawn by non-linear loads.



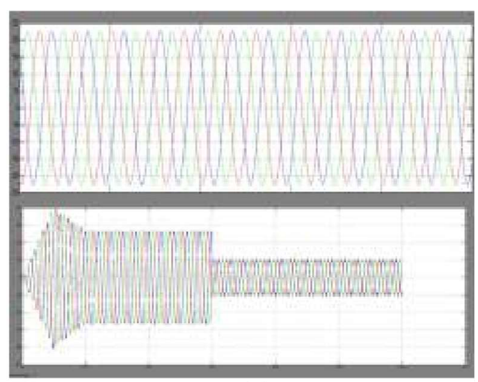
a) Source voltage and source current before harmonic compensation





(b) Active power and reactive power before

The results show that the network current becomes perfectly sinusoidal after the control application. The injections of wind power don't affect DC link voltage reactive power is always zero. We can observed from [0s-0.3s], the opposite phase between voltage and current source and the negative sign of the utility active power (Ps), meaning the filter current has information of harmonic and wind turbine currents to ensure elimination of harmonic and injection of current to the load. The dc link voltage returns to its reference value in few milliseconds. From [0.3s-0.6s], the network current remain in phase with the corresponding voltages and the active power (Ps) become positive that meaning the filter current has just information of energy because there is no wind .



(a) Source voltage and source current after harmonic compensation

Isa(A)
Vsa/3
(V)
Vsabc

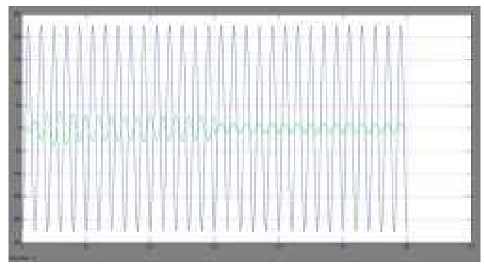
(V)
Ps
(W)

harmonic compensation

(c) Supply current before harmonics compensation and its harmonic spectrum

Vdc
(V)

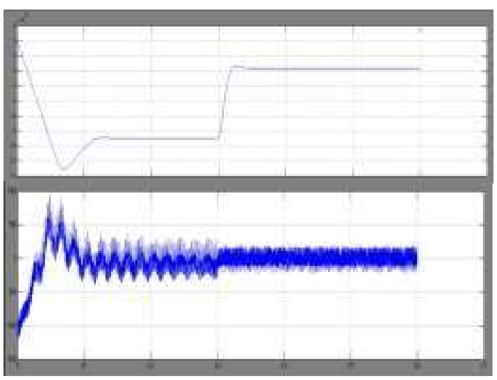
Isabc



Time(s)

(b) Source voltage and source current after harmonic compensation

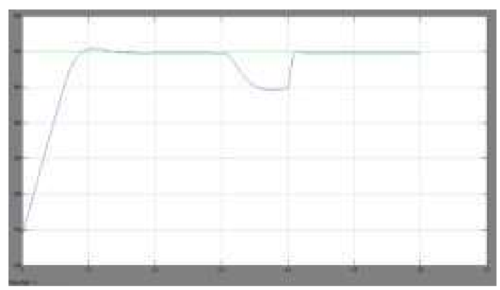
Qs



(W)

Time(s)

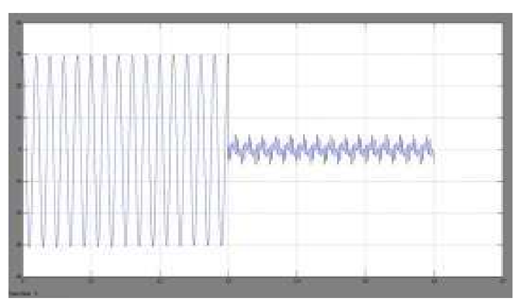
(c) Active power and reactive power after harmonic compensation



Time(s)

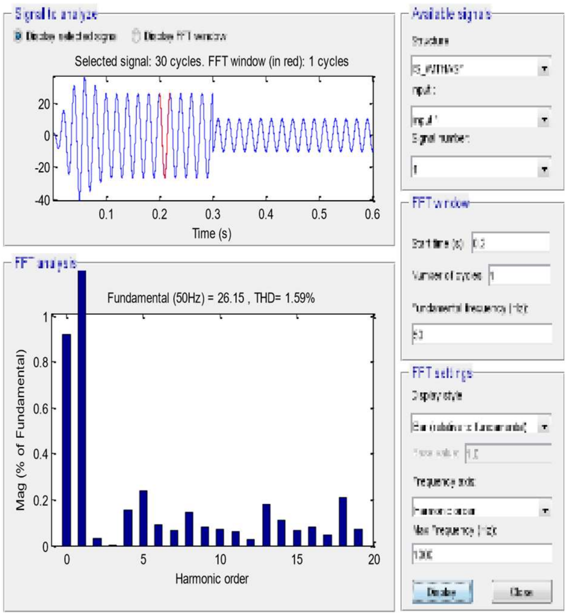
(d) : DC-link voltage after harmonic compensation

Ifa(A)



Time(s)

(e) : filter current after harmonic compensation



(f) supply current after harmonic compensation with WECS and harmonics spectrum

V.CONCLUSION

This paper focused on applying direct power control to a three-phase multifunctional grid-connected inverter interfaced with a wind energy conversion system. The proposed control scheme is used in order to achieve harmonics elimination, reactive power compensation, and simultaneously inject the active power available from the PMSG wind turbine into the load and/or grid. The analysis of the simulation results obtained has attested the robustness, the effectiveness and the good performance of proposed system. The DPC method has very good performance in PMSG wind turbine to the distribution networks and simultaneously compensating harmonics and reactive power.

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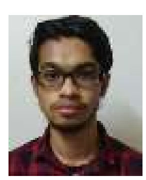

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