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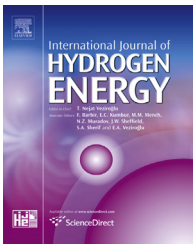

Exploration of optimal design and performance of a hybrid wind-solar energy system

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ABSTRACT

Clean energy solutions become very important in order to struggle with the increasing demand and pollution. In this paper, new hybrid trends in power electronic for the integration of wind energy conversion system (WECS) and photovoltaic power generator this later connected to the grid line via parallel active power filter (APF) are presented. The aim of this new hybrid configuration is to respond simultaneously to the power generation by both active power and reactive power compensation and harmonics current mitigation by active filtering capability fed by solar energy. The proposed WECS based on a doubly fed induction generator (DFIG) with the directly grid-connected stator and rotor through a back-to-back AC-DC-AC pulse-width modulation (PWM) converter. Two controls strategy were carried out following the field oriented control (FOC) method, the first was applied for the rotor side converter (RSC) in order to ensure a decoupled control of the maximum active power which is extracted by the maximum power point tracking algorithm (MPPT) and reactive power and also a small harmonic compensation. The grid side converter (GSC) is controlled by the second strategy in such way to guarantee a smooth DC voltage shared between the two converters. In order to ensure a perfect compensation of the most leading harmonics caused by the nonlinear load a proposed photovoltaic system (PVs) was connected to the grid via active power filter which is controlled by the instantaneous reactive power theory (p-q theory). Besides, the proposed PVs export the maximum active power to the grid using a perturbed and observed MPPT algorithm and boost converter. Furthermore, this paper provides a study of the proposed hybrid system response under varied wind speed of the DFIG and varied values of the nonlinear load in order to prove the performance of this new proposed approach. The software that has been incorporated in designing is Matlab/Simulink.

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Introduction

Because of its clean and renewable nature, wind energy is counted as a very important resource among the other clean energy sources in the world. However, its hybrid usage with other renewable energy sources such as the solar energy has been an important task in order to solve the energy problems to compensate the increasing demand due to the population and dissemination of the clean energy production [1–3]. With the increasing threat of global warming and the depletion of fossil fuel reserves, such hybrid renewable energy generations are becoming the most effective solution to meet our energy demands [4].

The intermittent natures of the wind and PV systems make them unreliable which is considered as the common inherent drawback, wind energy, by itself proved a good capability for supplying high power amounts, but its stability is still not predictable in the absence of the wind [5,6]. Similarity, the solar energy efficiency is depending to the level of the solar irradiation variation, because of the sun's intensity and shadow effects stem from trees, birds, clouds, etc. [7,8]. In order to enhance the efficiency and the reliability of the intermittent renewable sources, a wind/solar hybrid systems proved several advantages as an alternative solution in this manner [9]. Often there is plenty of wind, but there exists no sun and that situation may become insufficient to meet the load demands. This situation also can be considered vice-versa. Then the deficit can be compensated perfectly by the other energy source.

Many low power wind turbine systems use the squirrel-cage induction machines for the conversion of wind energy into the electrical energy. They can be also adopted for the power grid connection [10]. On the other hand, a numerous drawbacks of this kind of turbines exist such as operating at a fixed rotating speed, which prevent to attain the maximum amount of the power [11]. Therefore, wind generators with variable speed are frequently used and they get much interest than the fixed-speed systems, due to their efficient energy production. This kind of turbine based on doubly fed induction generator is interconnected to grid via two back-to-back using PWM converters named as RSC and GSC [12]. Frequently the RSC provides a decoupled control of the active and the reactive power independently using the d-q component control of the rotor current thus variable wind speed become possible in order to maximize the output power of the wind turbine. The

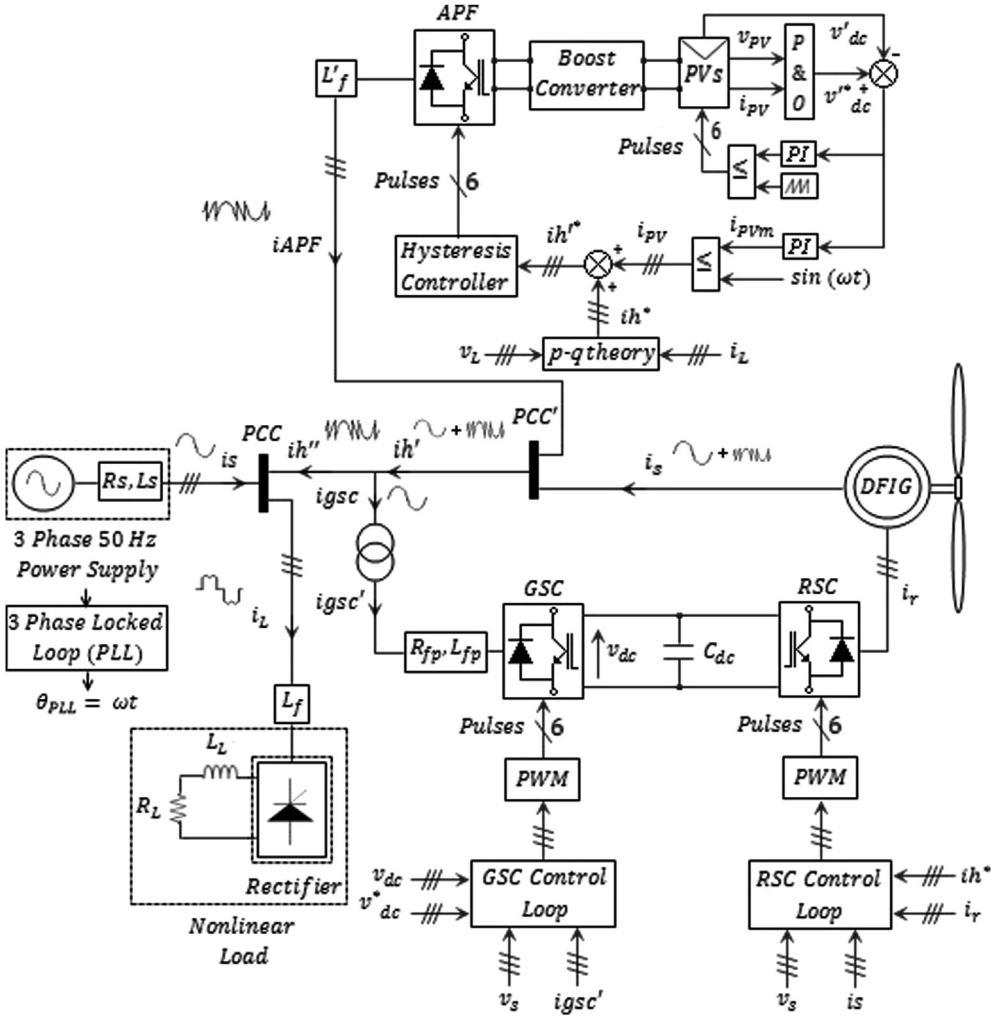

Fig. 1 – Overall circuit diagram configuration of hybrid wind solar energy system.