

# Improved Control of Current Controlled Grid Connected Inverters in Adjustable Speed Power Energies

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**Abstract.** This Paper presents a comparison of two control strategies applied to current controlled inverters in renewable energy systems. The strategies are the Synchronous Reference Frame and Stationary Reference Frame. First control method use PI regulators and it is the most used inverters control. In this paper, it is shown how to simplify the parameters design of the Proportional-Resonant controller for the Stationary Reference Frame. This paper presents the grid model and detailed design and stability analysis with a modified Symmetry Criterion method for the PI regulator parameters calculus. From this point, we transform the designed PI regulator into a PR, which it's needed for the Stationary Reference Frame Control. Results in terms of THD<sub>i</sub> indicate the better performance of PR control.

## Key words

Synchronous Frame, Stationary Frame, Resonant Controllers, Voltage Oriented Control, Voltage Source Inverters, Symmetry Criterion.

## 1. Introduction

Nowadays, Wind Turbine Systems Generators (WTSG) with Direct-Drive Permanent Magnet Generator (DDPMG) is one of the preferred technologies in variable speed. Wind turbine usually rotates at the speed of 30-50 rev/min, and generators should rotate at 1000-1500 rev/min to interface directly with the grid. Usually, a gear box should be connected between wind turbine and the electric generator. Direct connection of the generator to the wind turbine requires a large number of poles. Permanent Magnet Synchronous Generators (PMSG) are the best choice to be used, with a small pole pitch and cost-effective design.

Wind turbine system is known to have a slow response, this kind of systems are suitable for grid connection applications in which the dynamics requirement can be demanded by a slow current ramp. We have to manage the extracted energy from WTSG to the grid via a fully scale Back-to-Back converters. Generator side converter

aims to control the output power from the DDPMG thanks to Maximum Power Point Tracking algorithm.

Power flow is balanced via the DC link to the Grid Side Power Electronic Converter. It aims to maintain the DC-Bus voltage and translates the generated energy to the grid through its inductance filter. As the inductor is made smaller it improves the ability to track the desired reference current, however we have to increase the switching frequency to reduce current line ripple.

In this paper, PI regulator parameters are calculated in the Synchronous Reference Frame. This method is based on voltage space-vector oriented reference frame, also called Voltage Oriented Control (VOC). Then, Power is controlled thanks to the current regulators, which are the control mode of our Voltage Source Inverter (VSI).

Classical PI regulators are unsatisfactory for Stationary Reference Frame (AC control). We have to use a Proportional-Resonant controller to resolve the problem. Resonant Controllers don't have to transform a measured stationary frame ac current to rotating frame dc quantities. If transformation is not accurate errors could be introduced at the synchronous compensation network. Stationary frame controller is obtained using the transfer function proposed in.

Control scheme has been implemented using Matlab Simulink®. Paper presents the comparison results from the point of view of the harmonic content of injected currents (THD<sub>i</sub>).

## 2. Conclusion

This Paper presents a comparison of the *Synchronous Reference Frame (VOC)* applied to grid voltage) and *Stationary Reference Frame* control strategies used in VSI current mode control.

Paper starts providing background on the grid model and *VOC PI regulator* parameters are obtained with a modified *Symmetry Criterion* method. From this point we transform the PI regulator into a *Proportional-Resonant* controller which will be used in the Stationary Reference Frame.

Control strategies proposed has less harmonic content at third interval of simulation (600ms to 900ms) when grid voltages are 0.9pu. This is motivated by the bigger system PWM gain than first and second intervals. With a High Gain PWM system can follow the control current references better.

Simulation results shown in terms of  $THD_i$ , indicate that PR control improves  $THD_i$  with the same dynamic characteristics of VOC control. At the worst case (second interval) PR control presents an interval average  $THD_i$  of 2.41%, meanwhile VOC has 2.88% at the same interval with compensating terms strategy. The relative improvement is up to 16%. It's known that Stationary Frame control needs less mathematical calculus than a Voltage Oriented Control. PR control is a good alternative to implement an inverter system control with reduced harmonic content injected into the grid and less computational load than VOC control.

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