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Grid-Current-Feedback Active Damping For *Lcl* Resonance In Grid-Connected Voltage Source Converters

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ABSTRACT

The use of LCL filters in pulse width modulation voltage source converters is a standard solution for providing proper attenuation of high-order grid-current harmonics. However, these filters can cause the undesired effect of resonance. This paper proposes an active damping strategy with harmonics compensation. It can alleviate the harmonics around the resonance frequency caused by the LCL filters. The proposed strategy is attractive since it is simple, does not depend on grid parameters and does not increase the number of sensors. Simulation and experimental results verify the effectiveness of the proposed active damping strategy.

INTRODUCTION

Distributed Generation (DG) systems based on renewable energy sources are experiencing rapid development. Pulse width modulation (PWM) voltage source inverters (VSI) are increasingly used to connect these different sources to power system. For the reduction of grid current ripples, LCL filters are often used as the output stage of grid-connected inverters. Nevertheless, LCL filters bring undesired resonance effects, which are caused by the zero impedance for some higher order harmonics of grid-connected current. In order to solve this problem, passive and active damping methods have been presented in some literatures. Passive damping is a simple way to guarantee system stability, but there is a decrease in the overall system efficiency caused by the added resistance. To avoid such losses, a method which is called "virtual resistor" was presented. However, it requires an extra capacitor current sensor. Furthermore, two or even three loop active damping control is adopted.

PROPOSED SYSTEM

The active damping method with only grid current feedback is proposed. Compared with the most widely used capacitor current feedback active damping, this novel method avoids the use of extra sensors to detect the capacitor current, which possesses the merits of lower cost and higher reliability. By performing the equivalent control block diagram transformation, it is revealed that a virtual impedance in series or parallel with the grid-side inductor can ideally be implemented with specific active damping controllers, which also comprehensively reflects the physical circuit property of grid current feedback active damping.

CONTROL OF GRID-CONNECTED CURRENT:

It is worth highlighting that the introduction of one delay in the current loop has an effect on the system. Usually one delay in the current loop makes the system more stable and reduces the need for damping. The stability adopted grid side current feedback is prior to that of the converter side current feedback. On the other hand, the use of grid side current feedback is reasonable since one of the main objectives is the control of the power factor at the point of the grid connection. Therefore, the proposed active damping method is based on grid side current control. A cascaded control structure with an outer dc link voltage control and inner current control loops is used in this paper.

The outer dc-link voltage is beyond the scope of this paper, so its dynamics and control are not discussed. The current control loop consists of a current controller, an

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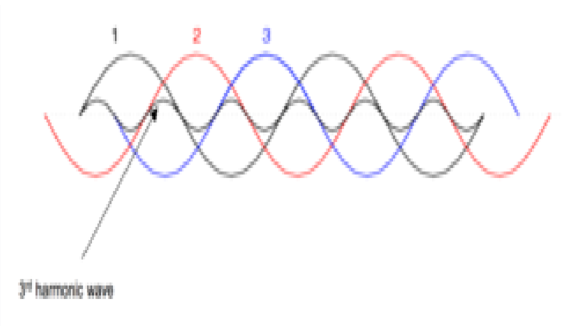
active damping block and a Phase Lock Loop (PLL). Usually, proportional-Integral (PI) controllers, used as grid-connected current control, are not able to track a sinusoidal reference without steady-state errors.

Non-linear loads create disturbances in the fundamental harmonic, which produce all types of harmonics. However, in this section we focus on the 3rd order harmonic due to its certain special characteristics in the context of powers systems.



3rd Order Harmonic Addition

Power is supplied by a three phase system, where each phase is 120 degrees apart. This is done for two reasons: Firstly it is because generators/motors that use three phases are more efficient due to the constant torque the phases supply, and secondly it is because after power is supplied to a load, the three phases can theoretically be added onto a neutral wire and cancels each other out. This saves the utility from creating return wiring to the power plant. However, if the 3 phases contain 3rd order harmonics, the currents will not fully add to zero. As seen in the figure, the 3rd harmonic will add constructively with the 3rd harmonics within the other phases. This leads to an oscillating current in the neutral wire, which can be dangerous since it is designed (i.e. small-size conductors) to carry minimal current. To avoid 3rd harmonics adding together Delta connections are used, and the current is cycled around the connection instead of combining into the neutral of a Wye connection.

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The simplest way to generate a PWM signal is the intersective method, which requires only a saw tooth or a triangle waveform (easily generated using a simple oscillator) and a comparator. When the value of the reference signal (the red sine wave in figure 2) is more than the modulation waveform (blue), the PWM signal (magenta) is in the high state, otherwise it is in the low state.

CONCLUSION

The grid current feedback active damping for LCL resonance damping in grid-connected VSI system is analyzed. Compared with the widely used capacitor current feedback active damping method, the proposed method can save the extra sensors making the cost lower and system more reliable. This paper has presented a simple active damping solution to improve the system performance. And the current harmonics caused by resonance is compensated by the proposed strategy. Simulations and experiments have been performed with a 5 kW experimental setup to verify the effectiveness. The strategy does not increase additional sensors and is easy to implement, which is suitable for industrial applications.

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