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Control Strategies Of Three-Phase Distributedgeneration Inverters For Grid Unbalanced Voltage Compensation

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ABSTRACT

This paper presents a new nonlinear current control strategy based on back stepping control and high-order sliding mode differentiator in order to employ distributed generation (DG) unit interfacing converters to actively compensate harmonics/ inter harmonics of local loads. The converter-based DG unit is connected to a weak grid (with uncertain impedance) and local load through an LCL filter.

The proposed strategy robustly regulates the inverter output currents and delivers pure sinusoidal, three-phase balanced currents to the grid. The new controller demonstrates the robust performance and robust stability of the DG unit system with respect to the filter parameters uncertainties, grid impedance, grid frequency, and grid voltage as well as the unknown load dynamics that include unbalanced loads and nonlinear loads with harmonic and inter harmonic currents.

We should remark that the local compensation of the loads with inter harmonic current using a DG unit system is first proposed in this paper.

INTRODUCTION

The increased application of nonlinear loads such as computers, variable-speed drives, and compact fluorescent lamps, as well as power-electronics-based distributed generation (DG) systems may lead to distribution system harmonic pollutions. To compensate distribution system harmonic issues, a number of active and passive filtering approaches have been proposed. Conversely, installing additional filters is not cost effective. Simultaneously, renewable energy sources (RES) are connected to the grid using current-controlled voltage source converters with output L-type or LCL-type filters. Although grid-connected DG units may introduce harmonics into the power system and distort the power quality of the distribution system, they are also able to improve the distribution system power quality by cancelling the harmonic currents of local loads through modifying control references

To compensate for the local load harmonic current, many types of harmonic extraction approaches have been suggested, including instantaneous power (pq) theory, second order generalized integrator (SOGI), the delayed-signal cancellation- based detection, and Fourier transformation based detection. To reduce the computational burden of DG unit controllers, the harmonic detection-less method has been proposed. The main grid current commonly needs to be free of harmonic distortion. To improve the power quality of the grid current, the DG unit compensates for the harmonic current drawn by the nonlinear loads through injecting harmonic current. Therefore, the grid current will become free of distortion and the result will be good voltage quality at the point of common coupling (PCC).

It becomes more important for a weak grid, where the harmonic current flowing through high grid impedance may cause more voltage distortions at the PCC. As a result, the improvement of the distribution system power quality through the proper control strategy of DG is an issue with high potential for engineering solutions. To attain a high-power quality DG, many strategies for harmonic compensation have been investigated. Harmonic compensation methods can be divided into two categories: selective and non-selective scheme. Many selective harmonic compensation strategies use a current controller based on proportional-integral (PI) control in the rotating reference frame of each harmonic.

A number of works that combine sliding mode control with conventional control have been proposed for harmonic compensation. They are shown to be insensitive to parametric uncertainties and external disturbances.

Although the sliding mode control method reduces harmonics under undesirable load conditions, the undesired chattering phenomenon is a major drawback of sliding mode control causing low power quality and instability. The idea of harmonic filtering via point of connection (PoC) using current-controlled grid-connected DG. This method works according to the shunt active power filter (APF) capability of DG, where the DG unit improves the distribution system power quality by cancelling the harmonic currents of nonlinear loads. Finally, the DG unit delivers an improved source current and PCC voltage with lower total harmonic distortion (THD).

EXISTING SYSTEM:

In this paper, two control strategies for power electronics interfaced Distributed Generation (DG)s are proposed in order to compensate the grid steady-state unbalanced voltage caused by unbalance loads. Both proposed methods are based on the DG's

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equivalent negative sequence virtual impedance amplitude and phase angle control. In the first strategy, DG's active power oscillation is minimized in order to reduce the adverse effects of compensation on the DG's operation.

This method is named as active power oscillation minimization in this paper. In the second strategy, an effective method for reducing the negative sequence voltage of the grid is proposed in which the DG's injected negative sequence current is controlled to be in the same phase with the grid negative sequence current.

PROPOSED SYSTEM

The proposed strategy robustly regulates the inverter output currents and delivers pure sinusoidal, three-phase balanced currents to the grid. The new controller demonstrates the robust performance and robust stability of the DG unit system with respect to the filter parameters uncertainties, grid impedance, grid frequency, and grid voltage as well as the unknown load dynamics that include unbalanced loads and nonlinear loads with harmonic and inter-harmonic currents. We should remark that the local compensation of the loads with inter-harmonic current using a DG unit system is first proposed in this paper. When compared with the popular parallel proportional resonant (PR) control technique, the proposed controller offers smoother transient responses and a lower level of current distortion.

The local loads are connected to the PCC, which are placed at DG unit terminals. The DG output currents are regulated by the proposed controller, while the harmonic extraction block extracts the loads harmonic/inter-harmonic currents and produce the harmonic/ inter-harmonic currents references to inject a set of pure sinusoidal balanced three-phase grid currents. L1 is the inverter-side inductor along with parasitic resistance; L2 is the grid-side inductor along with parasitic resistance; and C is the filter capacitor.

The state space equations of the DG grid-connected system in the stationary abc-frame with the isolation of grid-neutral N can be represented through the following equations:

$$L_1 \dot{i}_{1_{abc}}(t) = u_{abc}(t) - v_{abc}(t) - R_1 i_{1_{abc}}(t)$$
$$C \dot{v}_{abc}(t) = i_{1_{abc}}(t) - i_{2_{abc}}(t)$$
$$L_2 \dot{i}_{2_{abc}}(t) = v_{abc}(t) - R_2 i_{2_{abc}}(t) - V_{PCC_{abc}}(t)$$

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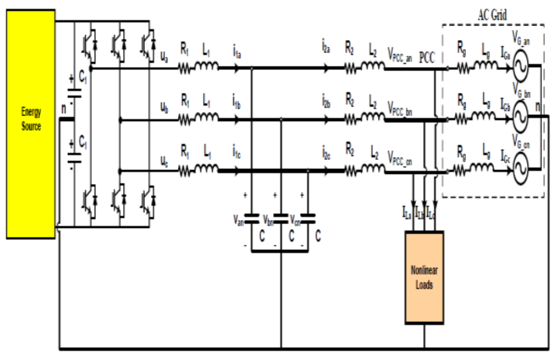

Fig: 3.1 Circuit diagram of a three-phase four-wire grid-connected inverter.

CONCLUSION

A new harmonic and inter-harmonic compensation strategy is proposed for DG interfacing converters with LCL filters. The proposed method combines a back stepping control system based on a high-order sliding mode differentiator. The DG unit is connected to a weak grid (with uncertain impedance) and a local load (which can be parametrically uncertain and topologically unknown) through an LCL filter. In this paper, a new harmonic and inter harmonic compensation strategy is proposed for DG interfacing converters with LCL filters. The proposed method combines a back stepping control system based on a high-order sliding mode differentiator. The DG unit is connected to a weak grid (with uncertain impedance) and a local load (which can be parametrically uncertain and topologically unknown) through an LCL filter.

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