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A Three-Phase Boost-Type Grid-Connected Inverter Based On Synchronous Reference Frame Control

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ABSTRACT

In this paper, a synchronous reference frame (SRF) controlled three-phase boost-type grid-connected inverter with Current Space Vector Modulation (CSVM) is proposed for alternative energy sources regenerations.

The averaged model of the equivalent boost-type inverter on SRF is derived in this paper. With the proposed averaged model, a SRF-PI compensator is analyzed with Bode diagram in frequency domain.

Hence, the steady-state error tracking of the current can be effectively eliminated and power factor of the inverter can be well controlled under the decoupled d-q SRF control strategies.

INTRODUCTION

In distributed power generation systems, current source inverter (CSI) has gained more and more attentions, since it has many advantages compared to voltage source inverters, such as low ripple of dc side currents, low input voltages, and single-stage energy conversions. Besides the topology analysis, many articles have been reported regarding the control strategies on the CSI. For example, a one-cycle control (OCC) to regulate the delivered output power by controlling the dc side inductor current. The control scheme was simple and the experimental results shown the dynamic response was fast. But the output currents were not directly controlled, thus the power factor displacement caused by output filter could not be effectively reduced.

Some other advanced controllers based on hysteresis, synchronous frame PI, and stationary frame P+Resonant control principles, have been applied to CSI voltage regulation. As reported, steady-state zero tracking and high-quality transient performance have been achieved. However, the phase delay caused by dc side inductor was not referred since the control strategy was based on an ideal current source model. As a consequence, a two loop control strategy for the three-phase boost-type inverter is proposed in this paper. Thanks to the idea of SRF control for traditional VSI, an external loop is designed and implemented in d-q synchronous frame to control the output currents accurately. In addition, there is an inner loop to enhance the dynamic performance of the system. Furthermore, the modeling of the three-phase boost-type inverter is investigated and the loop gains of the system have been analyzed in frequency domain.

Due to global warming and green house gas effects, the importance of non-conventional energy sources is increasing day by day. Among them, solar energy is very promising. At present, one of the reasons for its limited usage is the cost. In a grid connected photovoltaic system, the cost of the equipment other than the solar cells **is** estimated to be 50 percent of the overall cost**.** Hence, reducing the cost of the inverter **is** very important. Nowadays photovoltaic (PV) inverters are using IGBTs **as** switching devices. Conventional thyristors are economical compared to IGBTs. So replacement of IGBTs with thyristors can be a good option for cost reduction. The basic active commutated thyristor .CSI with pulse width modulation (PWM) capability has been recently implemented with a resistive load by Ashish Bendre et al.**.**

The six IGBTs of the bridge have been replaced by six thyristors, and the active commutation of thyristors is achieved by placing a controlled switch across the bridge. In this work sine triangle PWM technique has been used which suffers from poor dc link current utilization. A CSI has an inherent stability problem due to resonant frequency oscillations of LC filter. In these oscillations have been damped out actively by generating a damping current from the output capacitor voltage. Eigen value analysis has been carried out to study the stability of CSI fed IM drive.

Although modulation and control strategies for a CSI are much less developed than for a VSI, some advances have been made in applying pulse width modulation (PWM) theory to the control of these inverters [3], [4]. More recent work has also shown that, while the two topologies are not exact duals, they do have much in common in a space-vector sense and, hence, modulation strategies that are optimized for a VSI can be applied to a CSI with little modification to achieve similar harmonic benefits. The dual of current regulation for a VSI is voltage regulation for a CSI. However, to date the only voltage regulation strategies that have been reported for a CSI have used simple proportional– integral (PI) feedback in the stationary frame, and this type of control is well known to suffer from steady-state magnitude and phase errors for ac reference signals. In drive applications,

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this can lead to under excitation and reduced torque or output power for the motor.

This paper shows how current regulation strategies for a VSI can be directly implemented as equivalent voltage regulation strategies for a CSI. Hence, the more effective closed-loop strategies, such as hysteresis, synchronous frame DQ, stationary frame P Resonant, and predictive control, can be immediately applied to a CSI to achieve precise output voltage control without magnitude and phase errors. The approach presented is general and requires minimal modification from the VSI counterparts to be implemented. For the grid connection of photovoltaic (PV) energy sources, several PV modules are typically wired in series strings. These strings can be paralleled and tied up to a central inverter station or can be directly interfaced by separate (multi-) string inverters. However, both configurations allow limited modularity, and the string or even the whole array can only be operated at a single maximum power point (MPP).

EXISTING SYSTEM

In this paper, the one-cycle control (OCC) method and the conventional pulse width modulation (PWM) method are proposed based on the CSI topology for a grid-connected application.

The property of single power stage is preserved and the input dc voltage of the inverter is lower than the output peak grid voltage, which perfectly suits the property of wide output voltage range in PV or fuel cells. The dc side inductance can be kept small in a balanced three-phase system, so the size, weight, and power dissipation of the dc inductor are reduced and system dynamic response is improved.

The proposed OCC method features a simple control circuit, fast transient response, and good stability. Multipliers or microprocessors are not necessary for a three-phase OCC control algorithm, while the maximum power point tracking (MPPT) capability can be conveniently integrated into the control core with an acceptable precision.

PROPOSED SYSTEM

A synchronous reference frame (SRF) controlled three-phase boost-type grid-connected inverter with Current Space Vector Modulation (CSVM) is proposed for alternative energy sources regenerations. The averaged model of the equivalent boost-type inverter on SRF is derived in this paper. With the proposed averaged model, a SRF-PI compensator is analyzed with Bode diagram in frequency domain.

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CONCLUSION

A modeling of a three-phase boost-type grid connected inverter has been built in d-q synchronous frame. A two-loop regulator has been designed. PI regulator has been used in outer loop, while a compensator of the phase delay caused by dc side inductor has been implemented in inner loop. In this paper, modeling of a three-phase boost-type grid-connected inverter has been built in d-q synchronous frame. A two-loop regulator has been designed. PI regulator has been used in outer loop, while a compensator of the phase delay caused by dc side inductor has been implemented in inner loop. With the regulator in synchronous frame, the current power factor of inverter is convenient to be controlled. Unity power factor of the output currents as well as the reactive power compensation can be realized. Furthermore, with the compensator of inner dc current loop, the system has a good dynamic response.

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