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A Novel Control Strategy for Grid Tied Inverters with Improved Power Quality

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Abstract:

A Novel Control Strategy For Grid Tied Inverters With Improved Power Quality Is Proposed In This Paper. The conventionalcurrent control strategies are analyzed and compared, andthen the necessity of A Novel control strategy is proposed toimprove the power quality. In the proposedcontrol strategy,the virtual resistance based on the capacitance current is used torealize active damping, zero compensation is brought in to enhance the stability, and the proportional resonant (PR) controller under two-phase static coordinate is designed to track the ac reference current as well as to avoid the strong coupling brought by thecoordinate transformation. Under the distortion grid voltage, thePR plus harmonic compensator (PR+HC) structure is adopted to restrain the distortion of the grid current. Finally, the proposedcontrol strategy is verified by the simulation results.

Index Terms:

Active power filter (APF), distributed generation (DG), distribution system, grid interconnection, power quality (PQ).

I. INTRODUCTION:

Distributed generation (DG) is emerging as available alternative when renewable or nonconventional energyresources are available, such as wind turbines, photovoltaic arrays, fuel cells, microturbines. Most of these resources are connected to the utility through power electronic interfacing converters, i.e., three-phase inverter. Moreover, DG is a suitable form to offer high reliable electrical power supply, as it is able to operate either in the grid-tied mode or in the islanded mode.

In the grid-tied operation, DG deliveries power to the utility and the local critical load. Upon the occurrence of utility outage, the islanding is formed. Under this circumstance, the DG must be tripped and cease to energize the portion of utility. However, in order to improve the power reliability of some local critical. LCL filter compared with the traditional L filter, it needs smaller inductance value and it is more effective for re-straining higher harmonic when they achieve the same filtering effect, but resonance problem exists in LCL fil-ter itself, it will cause system instability [1-3].

There are two common methods to solve it [4, 5]: one is passive damping, that is, a damping resistance is connected with the capacitor branch in series to inhibit resonance [6,7]. This method is simple and reliable, but the LCL filter's ability of restraining higher harmonic was reduced, it will also bring extra system loss for the damping resistor; another one is active damping, namely the modified control algorithm was adopted to inhibit resonance and make sure the system stability [8, 9].

According to the principle of inhibiting resonance by using damping resistance, and using equivalent transformation, a dual-loop control strategy for grid-connected inverter with LCL filter was proposed in this paper, this new method was used to inhibit resonance, ensure system stability. A detailed description about the process of proposing control strategy, mathematical modeling and decoupling control of grid-connected inverter in the DQ coordinate system, and the design method of controller parameter was given in this paper. Then system stability was analyzed, finally, the effectiveness and feasibility of the new method have been verified by simulation results.

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II.PROPOSED SYSTEM:

This paper proposes A Novel Control Strategy Inspired by the structure diagram of the passive damping method, the virtual resistance based on capacitance current is used to realize active damping, so the grid current loop can be stable. Then, the zero compensation on the corner frequency is brought in to enhance the stability. For three-phase LCL-filtered inverter, if coordinate transformation is adopted, the coupling between d and q-axis is more complex than L filter, so the outer proportional resonant (PR) controller under two-phase static coordinateis designed to track the ac reference current as well as to avoid the strong coupling.Moreover, the disturbance caused by grid voltage harmonics is investigated by determining the harmonic impedance of the current controller in [5], and tuning the currentcontroller parameters is used to mitigate this distortion, but the effect is limited. In this paper, PR + HC structure is adopted to increase the typical harmonic impedance, and power quality.

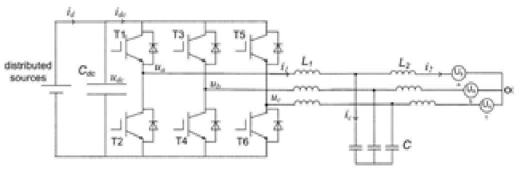

Fig. 1. Three-phase grid-connected inverters with LCL filter.

III.CONTROL STRATEGY:
Adoption of PR Controller:

Since PI controller cannot track the ac reference without error under static coordinate, it is replaced by a PR controller, considering Kr = Ki. To investigate the characteristic of the regulation, the open-loop Bode plot of the system using PI and PR controllers ,where the high-frequencyband of them coincide including the cutoff frequency, so the replacement of PR to PI does not affect the stability of the system.In addition, because PR controller has big magnitude at fundamental frequency, it can track the reference without error. When applied in αβ coordinate, the control structure is shown in Fig. 2. To verify the aforementioned analysis, simulation is

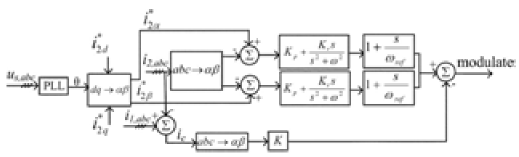

Fig. 2. Control structure applied under αβ coordinate.

done in Simulink using PI and PR controllers, respectively, and the result is given in Fig. 14, where the dotted line is the reference command current. From the simulation result, it's seenthat when a PI controller is used, the grid current has a staticerror to the reference; when a PR controller is used, the grid current tracks the reference current accurately. Moreover, whenthe reference current has mutation, dynamic response of the two controllers is similar. It's verified that PR controller has a better performance to track the ac reference command.

PR+HC Control Structure

In order to investigate the stability of the control system after HC part brought in, the Bode plots of PR controller , which can be seen that except some new harmonic peaks, the Bode plot of PR +HC controller coincides with the PR controller, so thestabilitymargins of them are the same. When applied under αβ coordinate, the control structure is shown in Fig.3. Simulations are done to verify the antiinterference function of the HC part. For comparison, simulations are done using PR controller and PR + HC controller. In which the total harmonic distortion (THD) of grid voltage is set to be 5%, by adding some typical odd harmonic.

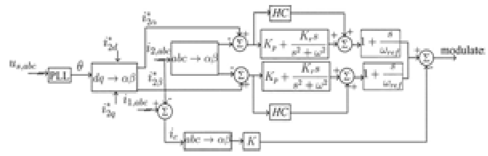

Fig.3. Control structure of PR+HC applied under αβ coordinate

IV.SIMULATION RESULTS:

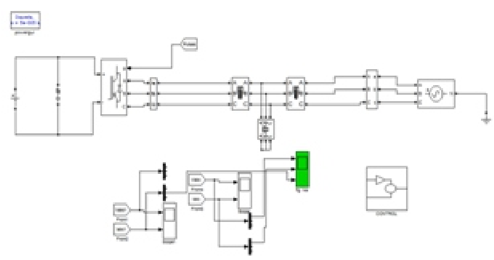

Fig.4simulation circuit

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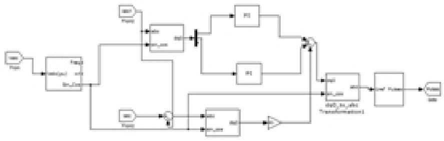

Fig.5. control strategy for PI controller used.

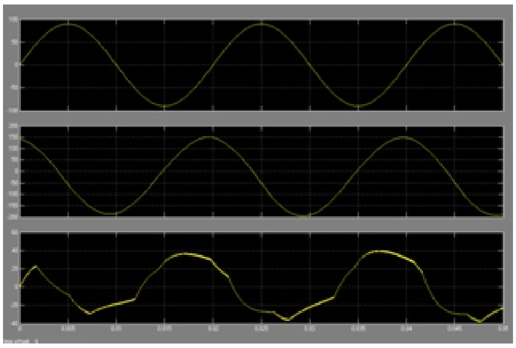

Fig.6 pi control waveforms, grid voltage, grid current, inverter current.

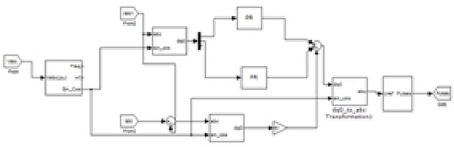

Fig.7. control strategy for pr

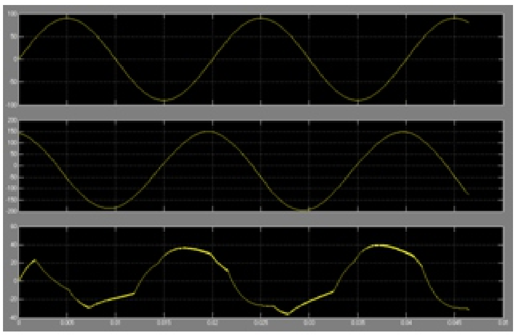

Fig.8 PRcontrol waveforms, grid voltage, grid current, inverter current.

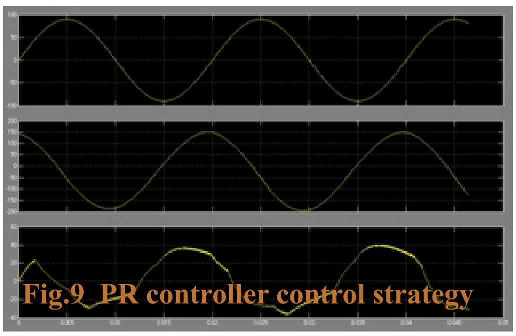

Fig.9 PR controller control strategy

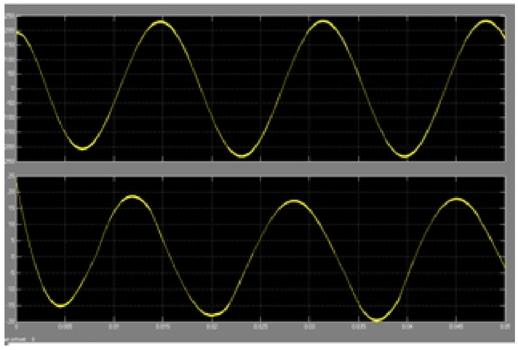

Fig.10. PR control waveforms, grid voltage, grid current,

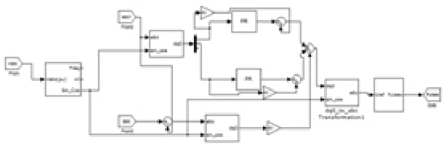

Fig.11 PR+HC controller control strategy

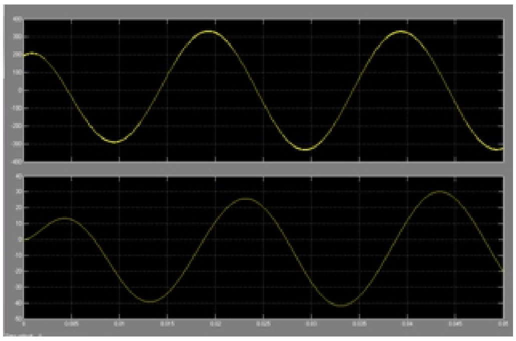

Fig.12.PR+HC waveforms, grid voltage, grid current,

V.CONCLUSIONS:

A Novel control strategy for grid-connected in-verter with LCL filter in this paper can be used to control the currents of three phase grid-connected inverter, and improve the power quality , harmonic suppression. A detailed description about theoretical basis of the control strategy and design method of the controller were given in this paper, the effectiveness of the new control strategy has been verified by simulation results.

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