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Control Strategy for Single-Phase Inverters in Distributed Generation Systems for improving Power Quality

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Abstract

This project deals with reactive power compensation and harmonic reduction by single-phase inverter for grid connected DG systems. The main theme is to integrate DG unit with shunt active Power filters. so that, the inverter controls the active power and performs the non linear load current harmonic by keeping grid current almost sinusoidal. The control scheme uses a current reference generator based on SSI and IRP theory together with repetitive current controller.

Key words: *Distributed power generation, power conditioning, and power quality. Matlab / simulink*

1. INTRODUCTION

Recently, due to the high price of oil and the concern for the environment, renewable energy is in the limelight. This scenario has stimulated the development of alternative power sources such as photovoltaic panels, wind turbines and fuel cells [1]–[3]. The distributed generation (DG) concept emerged as a way to integrate different power plants, increasing the D G owner's reliability, reducing emissions, and providing additional power quality benefits [4]. The cost of the distribution power generation system using the renewable energies is on a falling trend and is expected to fall further as demand and production increase.

The energy sources used in DG systems usually have different output characteristics, and for this reason, power electronic converters are employed to connect these energy sources to the grid, as shown in Fig. 1. The power electronic front-end converter is an inverter whose dc link is fed by an ac/dc converter or by a dc/dc converter, according with the DG source type. The commercial front-end inverters are designed to operate either as grid-connected or in island mode. In grid-connected mode, the voltage at the point of common coupling (PCC) is imposed by the grid; thus, the inverter must be current-controlled. When operated in island mode, the inverters are voltage-controlled, generating the output voltage at a specified amplitude and frequency[5], [6].

Coming to the grid-connected mode, almost all the commercial single-phase inverters for DG systems inject only active power to the grid, i.e., the reference current is computed from the reference active power $p*$ that must be generated [7]. It is possible and can be convenient to integrate power quality functions by compensating the reactive power and the current harmonics drawn by specific local nonlinear loads (see Fig. 1). The single-phase inverter can acquire active filtering features just adding to its control software some dedicated blocks that are specific to shunt active power filter (APF). This paper proposes and validates an enhanced power quality control strategy for single-phase inverters used in DG systems. The idea is to integrate the DG unit functions with shunt APF capabilities. With the proposed approach, the inverter controls the active power flow from the energy source to the grid and also performs the compensation of reactive power and the nonlinear load current harmonics, keeping the grid current almost sinusoidal.

2. **DISTRIBUTED GENERATION**

Distributed generation also called onsite generation, dispersed generation, embedded generation, decentralized generation, decentralized energy or distributed energy generates electricity from many small energy sources. Currently, industrial countries generate most of their electricity in large centralized facilities, such as fossil fuel (coal, gas powered) nuclear or hydropower plants. These plants have excellent economies of scale, but usually transmit electricity long distances and negatively affect the environment.

$$H_1(s)=\frac{I_{L1\alpha}(s)}{I_L(s)}=\frac{2k_A\times s}{s^2+2k_A\times s+\omega_0^2}=\frac{V_{1\alpha}(s)}{V_{PCC}(s)} \quad \text{………1(a)}$$

$$H_2(s)=\frac{I_{L1\beta}(s)}{I_L(s)}=\frac{2k_A\times \omega_0}{s^2+2k_A\times s+\omega_0^2}=\frac{V_{1\beta}(s)}{V_{PCC}(s)}. \quad \text{……….2(b)}$$

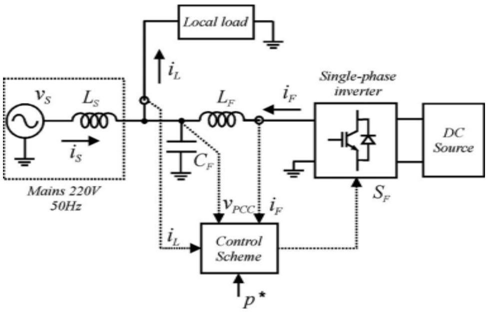
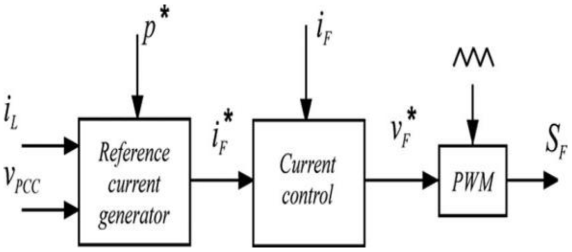


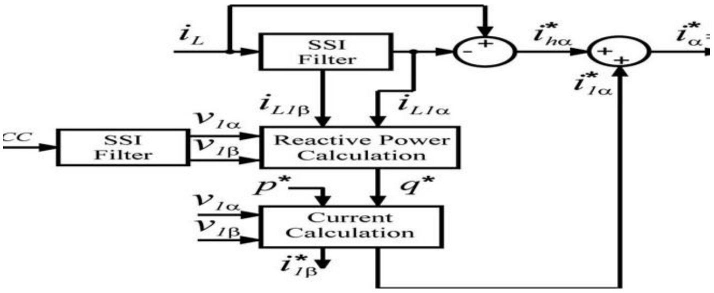
Fig. 1. General scheme of a DG unit connected to the grid.

3. INVERTER CONTROL SCHEME

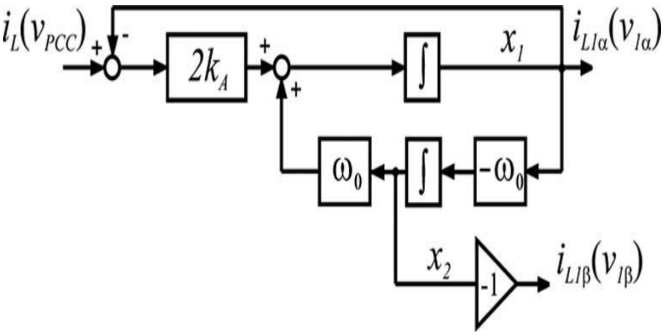
Inverter control scheme involves
1.Reference current generator
2. Current control
3. Pulse width modulation



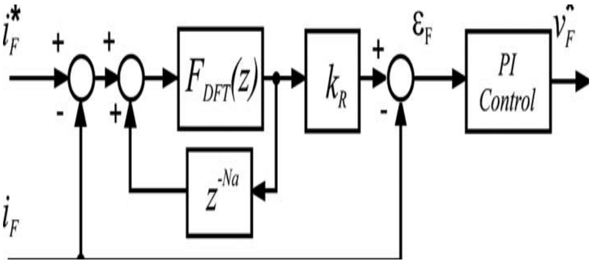
REFERENCE CURRENT GENERATOR:



SINUSOIDAL SIGNAL INTEGRATOR :



CURRENT CONTROL:



4. CONTROL STRATEGY

The p-q theory is based on the definitions of instantaneous active and reactive powers in the time domain by using instantaneous voltage and current components on αβ0 coordinates. So the p-q theory first utilizes Clarke Transformation to map three phase instantaneous voltages and line currents into αβ0 axes. Transformation matrices C and C-1 for Clarke transformation and inverse Clarke transformation are given respectively in (4.1) and (4.2).

$$\begin{bmatrix} v_0 \\ v_\alpha \\ v_\beta \end{bmatrix} = C \begin{bmatrix} v_a \\ v_b \\ v_c \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix} \begin{bmatrix} v_a \\ v_b \\ v_c \end{bmatrix} \quad \ldots(4.1)$$

$$\begin{bmatrix} v_a \\ v_b \\ v_c \end{bmatrix} = C^{-1} \begin{bmatrix} v_a \\ v_\alpha \\ v_\beta \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} \frac{1}{\sqrt{2}} & 1 & 0 \\ \frac{1}{\sqrt{2}} & -\frac{1}{2} & -\frac{\sqrt{3}}{2} \\ \frac{1}{\sqrt{2}} & -\frac{1}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix} \begin{bmatrix} v_0 \\ v_\alpha \\ v_\beta \end{bmatrix} \quad \ldots(4.2)$$

5. SIMULATION

MATLAB is a software package for high performance numerical computation and visualization, the analysis capabilities, flexibility, reliability and powerful graphics makes MATLAB the premier software package for all electrical engineers. MATLAB has been enhanced by the powerful SIMULINK program. SIMULINK is the graphical mouse-driven program for the simulation of dynamic systems. It enables the user to simulate linear, as well as nonlinear systems easily and efficiently.

5.1 SIMULINK MODEL FOR SSI FILTER:

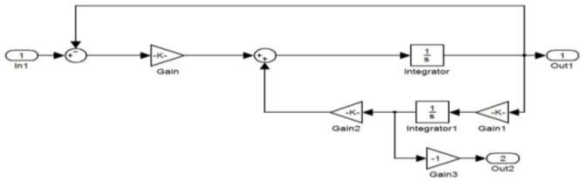


Fig 5.1simulation model for SSI filter

The Fig 5.1shows the simulation model for SSI filter. The operation of the SSI filter is when a single input is given to the filter, it splits the single component in to two components which are equal in magnitude but are phase shifted by 90°. This can be analyzed from the two transfer functions shown below.

$$H_1(S) = \frac{I_{L1\alpha}(S)}{I_L(S)} = \frac{2*K_A*S}{S^2+2*K_A*S+\omega_0^2} = \frac{V_{1\alpha}(S)}{V_{PCC}(S)} \quad \ldots(5.1.1)$$

$$H_2(S) = \frac{I_{L1\beta}(S)}{I_L(S)} = \frac{2*K_A*\omega_0}{S^2+2*K_A*S+\omega_0^2} = \frac{V_{1\beta}(S)}{V_{PCC}(S)} \quad \ldots(5.1.2)$$

5.2 SIMULINK MODEL FOR VALIDATION OF ACTIVE POWER GENERATION

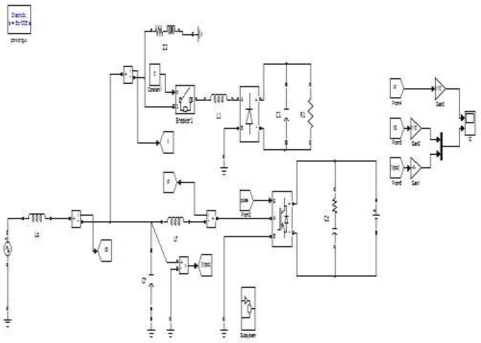


Fig 5.2 simulation model for validation of active power generation

The results for the circuit shown in fig 5.2 are shown below. They are inverter current (IF), grid voltage (VPCC) and grid current (IS)

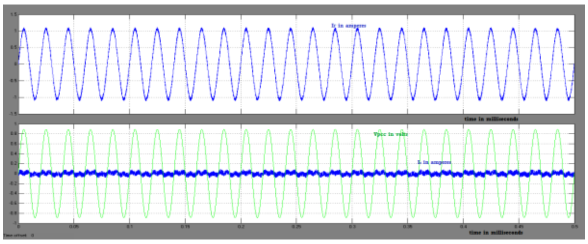


Fig 5.3. Steady-state operation of the inverter injecting the active power requested by the resistive load (2kW).

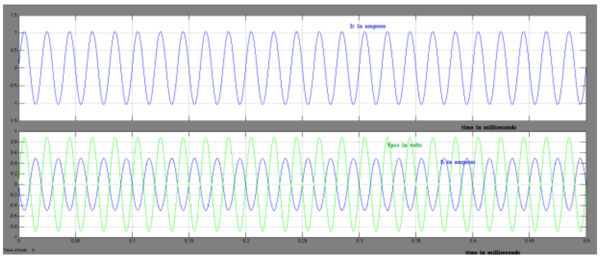


Fig.5.4 Steady-state operation for 3 kW active power generation. Only the 2 kW linear load is connected in this case

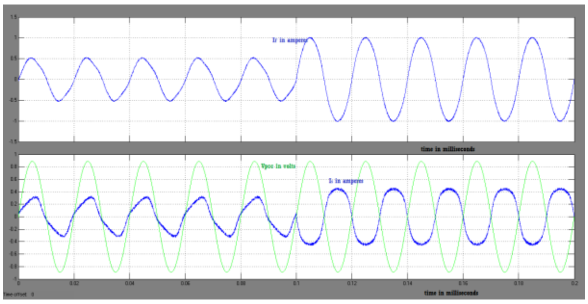


Fig. 5.5. Inverter transient response during a step-up of the injected active power (1–3 kW) when 2 kW linear load is connected

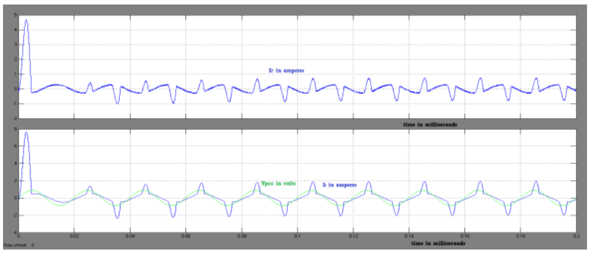


Fig.5.6 Steady-state operation of the inverter injecting 1 kW active power and compensating the current harmonics of the local load.

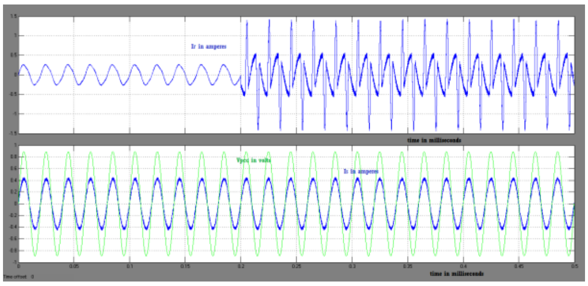


Fig 5.7 Inverter transient response during nonlinear load turn-on.

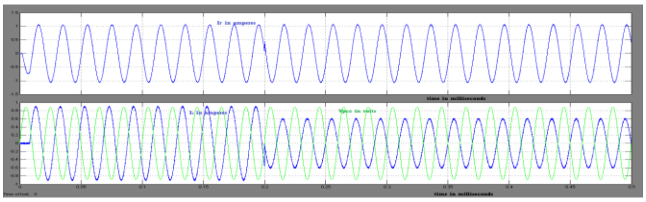


Fig. 5.8 Inverter transient response for step reactive power compensation when the injected active power is 3 kW.

CONCLUSION

This project deals with a single-phase inverter for DG systems, requiring power quality features as harmonic and reactive power compensation for grid-connected operation. The proposed control scheme employs a current reference generator based on SSI and IRP theory, together with a dedicated repetitive current controller. The grid-connected single-phase inverter injects active power into the grid and is able to compensate the local load reactive power and also the local load current harmonics. The simulation results have been obtained for different operating conditions, including active power generation, load reactive power compensation, and load current harmonic compensation. The results have shown good transient response and steady state response.

REFRERENCES

1. R.I.Bojoi , L.R.Limongi, Daniel Roiu and Alberto Tenconi “Enhanced Power Quality Control Strategy for Single Phase Inverters in Distributed Generation Systems” *IEEE Trans. Power Electron*, vol. 26, no.3,pp 793-806, March 2011.
2. T. E. McDermott and R. C. Dugan, “Distributed generation impact on reliability and power quality indices,” in *Proc. IEEE Rural Electr. PowerConf.*, 2002, pp. D3–D3_7.
3. F. Blaabjerg, R. Teodorescu, M. Liserre, and A. V. Timbus, “Overview of control and grid synchronization for distributed power generation systems,”*IEEE Trans.*

Ind. Electron., vol. 53, no. 5, pp. 1398–1409, Oct.2006.

4. F. Blaabjerg, Z. Chen, and S. B. Kjaer, "Power electronics as efficient interface in dispersed power generation systems," *IEEE Trans. Power Electron.*, vol. 19, no. 5, pp. 1184–1194, Sep. 2004.
5. P. Rodriguez, A. V. Timbus, R. Teodorescu, M. Liserre, and F. Blaabjerg, "Flexible active power control of distributed power generation systems during grid faults," *IEEE Trans. Ind. Electron.*, vol. 54, no. 5, pp. 2583–2592, Oct. 2007.
6. L. P. Kunjumuhammed and M. K. Mishra, "Comparison of single phase shunt active power filter algorithms," in *Proc. IEEE Power India Conf.*,2006, pp. 8–15.
7. M. K. Ghartemani, H. Mokhtari, and M. R. Iravani, "A signal processing system for extraction of harmonics and reactive current of single phase systems," *IEEE Trans. Power Electron.*, vol. 19, no. 3, pp. 979–986, Jul.2004.
8. L. P. Kunjumuhammed and M. K. Mishra, "A control algorithm for single-phase active power filter under non-stiff voltage source," *IEEE Trans.Power Electron.*, vol. 21, no. 3, pp. 822–825, May 2006.
9. L. P. Kunjumuhammed and M. K. Mishra, "A control algorithm for single phase active power filter under non-stiff voltage source," *IEEE Trans. Power Electron.*, vol. 21, no. 3, pp. 822–825, May 2006.
10. M. T. Haque, "Single-phase pq theory for active filters," in *Proc. IEEE TENCON Conf. Rec.*, 2002, pp. 1941–1944.
11. M. T. Haque, "Single-phase PQ theory," in *Proc. IEEE PESC Conf. Rec.*,2002, pp. 1815–1820.
12. M. T. Haque and T. Ise, "Implementation of single-phase pq Theory," in *Proc. IEEE PCC Conf. Rec.*, 2002, pp. 761–765.
13. M. Saitou and T. Shimizu, "Generalized theory of instantaneous active and reactive powers in single-phase circuits based on Hilbert transform," in *Proc. IEEE PESC Conf. Rec.*, 2002, pp. 1419–1424.
14. M. Saitou, N. Matsui, and T. Shimizu, "A control strategy of single-phase active filter using a novel d–q transformation," in *Proc. IEEE IAS Conf. Rec.*, 2003, pp. 1222–1227.
15. J. Liu, J. Yang, and Z.Wang, "A new approach for single-phase harmonic current detecting and its application in a hybrid active power filter," *Proc. IEEE IECON Conf. Rec.*, pp. 849–854, 1999.