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

Radu Iustin Bojoi, *Senior Member, IEEE*, Leonardo Rodrigues Limongi, Daniel Roiu, and Alberto Tenconi, *Senior Member, IEEE*

***Abstract*—Power electronic converters are commonly used for interfacing distributed generation (DG) systems to the electrical power network. This paper deals with a single-phase inverter for DG systems requiring power quality features, such as harmonic and reactive power compensation for grid-connected operation. The idea is to integrate the DG unit functions with shunt active power filter capabilities. With this approach, the inverter controls the active power flow from the renewable energy source to the grid and also performs the nonlinear load current harmonic compensation by keeping the grid current almost sinusoidal. The control scheme employs a current reference generator based on sinusoidal signal integrator and instantaneous reactive power (IRP) theory together with a dedicated repetitive current controller. Experimental results obtained on a 4-kVA inverter prototype demonstrate the feasibility of the proposed solution.**

***Index Terms*—Distributed power generation, power conditioning, power quality.**

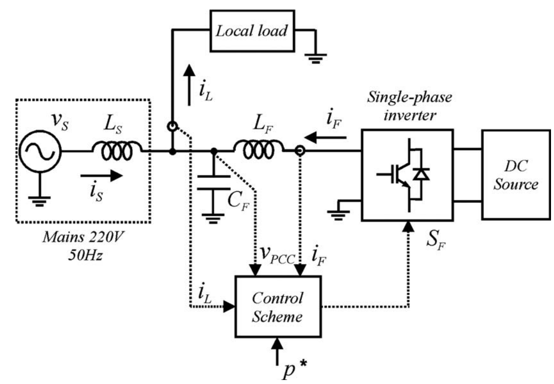

Fig. 1. General scheme of a DG unit connected to the grid.

I. 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 DG 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

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nonlinear load current harmonics, keeping the grid current almost sinusoidal.

The integration of APF capability in single-phase inverters needs a particular attention since the control techniques (for example, to find the reference current) were developed for three-phase APFs, and consequently, must be adapted for single-phase systems.

The literature presents different solutions to compute the harmonic extraction task for single-phase APFs [8]–[19]. The methods are classified in direct and indirect methods in [8]. The direct methods include the Fourier transform method [10], the instantaneous reactive power (IRP) theory [11]–[14] and the synchronous reference frame (SRF) theory [15]–[18]. On the other hand, the indirect methods include the use of enhanced phase-locked loop (EPLL) scheme or a controller such as proportional–integral (PI) to find the reference current [8], [9].

Among these solutions, the IRP and the SRF theories are the most addressed ones in the literature [11]–[18]. These strategies were originally proposed for three-phase systems, but they can be adapted for single-phase systems due to their effectiveness. In three-phase systems, both IRP and SRF techniques operate in a reference system with two orthogonal axes ($\alpha\beta$ for IRP and *dq* for SRF). In single-phase systems, since only one-phase variable exists, it is necessary to create one "fictitious" or imaginary variable in which all frequencies are phase-shifted by 90 electrical degrees with respect to the original variable. With this procedure, a system with two orthogonal variables is created from a single variable, allowing the application of the IRP and SRF theories. However, the computation of the fictitious variable from the existing one is not a simple task since the nonlinear load current has a high harmonic content. The imaginary variables are calculated in [14] by using the Hilbert transform. This method leads to a noncausal system and cannot be directly implemented. However, it is possible to approximate the transformation through a finite-impulse response (FIR) filter, and in this case, some phase delays are introduced in the fictitious variable and implicitly in the inverter current reference [19].

Alternatively, the computation of the reference current can be performed by using a sinusoidal signal integrator (SSI) along with the IRP theory. This approach has been originally proposed by the authors in [23] and allows obtaining without any delay the fictitious variables that are needed to apply the IRP theory or other techniques originally applied for three-phase systems. Moreover, the reference current computation is insensitive to grid voltage distortions. The authors in [23] experimentally validated only the current harmonics compensation features of the strategy since the inverter has been operated only as an active filter.

This paper shows the complete experimental validation of the proposed method for all its features, i.e., active and reactive power generation along with current harmonics compensation. Moreover, the paper employs a dedicated inverter current control scheme based on a repetitive controller implemented with a FIR filter approach. With respect to previous repetitive control solutions, the one proposed by the authors allows halving the number of the FIR filter taps, making the implementation easier from the point of view of the computational effort.

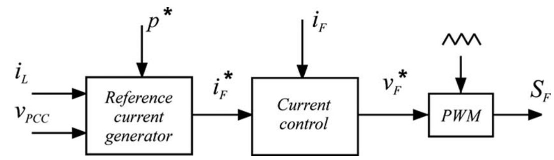

Fig. 2. Inverter control scheme.

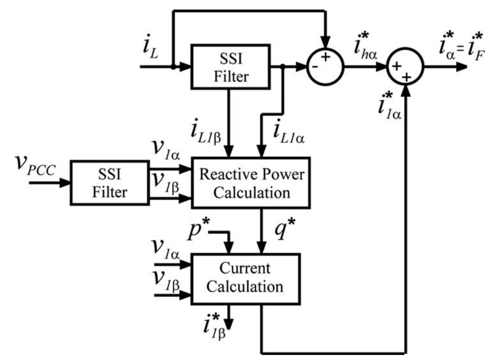

Fig. 3. Reference current generation scheme.

The paper is organized as follows. The inverter control scheme is discussed in detail in Section II, with a particular focus on the reference current generator and the current control implementation. Section III is related to the experimental results and contains a description of the testing setup followed by a complete experimental validation of the proposed control solutions. The experimental results are presented for the grid-connected inverter that generates active power and compensates the reactive power and current harmonics of local loads, thus achieving complete power quality features.

II. Inverter Control Scheme

The block diagram of the single-phase inverter control scheme with enhanced power quality features is shown in Fig. 2.

The inverter reference current i_F^* is generated by the reference current generator block and the current control is based on a repetitive controller.

A. *Reference Current Generator*

The reference current generation scheme is shown in Fig. 3 and can be divided into two parts: the computation of the harmonic current reference $i_{h\alpha}^*$ and the generation of the fundamental reference current $i_{1\alpha}^*$ corresponding to the active and the reactive power to be generated.

1) Generation of the Harmonic Reference Current: The nonlinear load current i_L and the PCC voltage $v_{\rm PCC}$ are used to calculate the reference current for current harmonics compensation. A filter based on SSIs (hereinafter called SSI filter) extracts the fundamental frequency component $\omega_0 = 2{\times}\pi{\times}50$ (in radian per second) of the load current in stationary $\alpha\beta$ frame, as shown in Figs. 3 and 4 [20]. The harmonic reference current $i_{h\alpha}^*$ is obtained from the subtraction of the load current from the output of the SSI filter ($i_L - i_{L1\alpha}$).

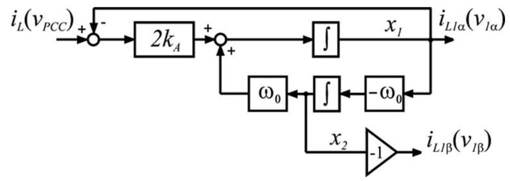

Fig. 4. SSI filter applied for the load current (input is i_L and the outputs are $i_{L\alpha}$ and $i_{L\beta}$) and for the PCC voltage (input is v_{PCC} and outputs are $v_{1\alpha}$ and $v_{1\beta}$).

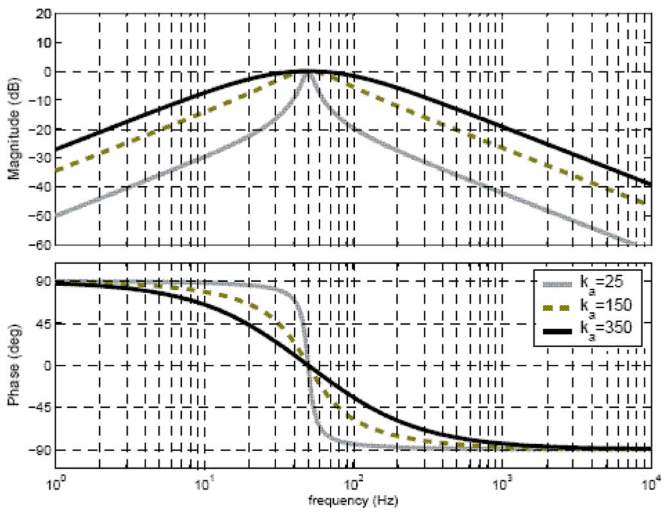

Fig. 5. Bode plots of $H_1(s)$.

2) Generation of the Fundamental Reference Current: In steady-state operation, the SSI filter shown in Fig. 4 has two sinusoidal states x_1 and x_2 having the same amplitude and being phase-shifted by 90 electrical degrees [20], [21]. So, it is possible to obtain two outputs from a SSI filter, $i_{L1\alpha}$ and $i_{L1\beta}$ (which is always 90° shifted respect to $i_{L1\alpha}$). This can be seen by analyzing the two transfer functions of the SSI filter

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

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

In steady-state operation, the relationship between the phases of the transfer functions (1) and (2) in the frequency domain is

$$\angle H_1(j\omega) = \angle H_2(j\omega) + \frac{\pi}{2}. \quad (3)$$

The Bode diagrams of (1) and (2) that are shown in Figs. 5 and 6 for different values of k_a confirm (3). It is also possible to see that when k_A becomes smaller, the filter becomes more selective. However, when this happens, the phase delay becomes higher around the fundamental frequency ω_0.

This property is useful for obtaining the orthogonal fundamental components needed to perform the reactive power compensation of the local load. The signal $i_{L1\beta}$ is generated by the SSI only to calculate the fundamental reactive power reference q^*, using the definition of reactive power from IRP theory as

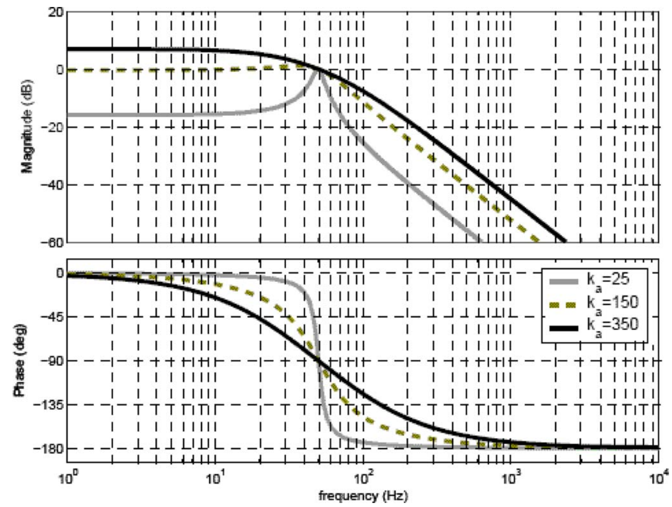

Fig. 6. Bode plots of $H_2(s)$.

follows:

$$q^* = i_{L1\alpha} v_{1\beta} - i_{L1\beta} v_{1\alpha}. \quad (4)$$

To obtain $v_{1\alpha}$ and $v_{1\beta}$, another SSI filter is used in the PCC voltage v_{PCC} by generating $v_{1\alpha}$ and a signal ($v_{1\beta}$) with the same amplitude and phase-shifted by 90 electrical degrees from $v_{1\alpha}$, as shown in Fig. 4. The use of an SSI filter in the PCC voltage makes the reference current generator insensitive to grid voltage distortions. The fundamental components of the inverter reference current $i^*_{1\alpha}$ and $i^*_{1\beta}$ are calculated by imposing the reference power p^* equal to the amount of active power to be injected into the grid, as follows:

$$\begin{bmatrix} i^*_{1\alpha} \\ i^*_{1\beta} \end{bmatrix} = \frac{1}{v_{1\alpha}^2 + v_{1\beta}^1} \begin{bmatrix} v_{1\alpha} & v_{1\beta} \\ v_{1\beta} & -v_{1\alpha} \end{bmatrix} \times \begin{bmatrix} p^* \\ q^* \end{bmatrix}. \quad (5)$$

Since the system is single phase, the current $i^*_{1\beta}$ is neglected and $i^*_{1\alpha}$ is added to the harmonic reference current $i^*_{h\alpha}$ to obtain the inverter reference current.The SSI filter used to extract the fundamental component of the nonlinear load current is very flexible, and the gain k_A (see Fig. 4) can be adjusted to improve the selectivity of the reference generator or to improve its transient response.

It is important to emphasize the difference between the solution used in this paper to create the fictitious variable and another existing method [14]. In the proposed technique, the orthogonal fundamental component signals, used for current reference generation and obtained from the SSI filter, are sinusoidal and phase shifted by 90°. In the existing method, the obtained fictitious variable is a signal with a high harmonic content generated by phase shifting all frequencies of the load current by 90°. In this case, some phase delay is introduced in the fictitious variable and implicitly in the inverter current reference [19].

B. Current Control

For inverters that generate active power and also compensate the reactive power, the reference current is sinusoidal at fundamental frequency, so the use of conventional PI controllers

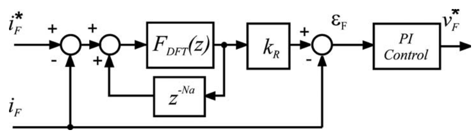

Fig. 7. Current control scheme.

would probably suffice if their bandwidth is high enough. If the inverter must also compensate the current harmonics, the reference current will become nonsinusoidal. In this case, achieving zero –steady-state error is not possible with PI controllers, unless particular control schemes are employed.

The adopted current control scheme is shown in Fig. 7 and is based on a repetitive controller along a conventional PI regulator in order to achieve zero steady-state error when the reference current has a high harmonic content. This scheme has been originally proposed in [22] for shunt APFs, and for this reason, it is also suitable for inverters used for active power generation and having power quality features.

Coming to the scheme in Fig. 7, the key issue is the implementation of the repetitive control scheme. The repetitive controller is nothing else than an FIR filter of N taps. The filter can be designed by using the discrete Fourier transform (DFT) to achieve unity gain for every single harmonic to be compensated. As described in detail in [22], the filter coefficients can be computed as

$$F_{\mathrm{DFT}}(z) = \frac{2}{N}\sum_{i=0}^{N-1}\left(\sum_{k\in N_h}\cos\left(\frac{2\pi}{N}h(i+N_a)\right)\right)z^{-i} \quad (6)$$

where N is the number of the coefficients, N_h is the set of selected harmonic frequencies, and N_a is the number of leading steps necessary to maintain the system stability. The k_R parameter from Fig. 7 influences the repetitive controller speed response [22].

The number of FIR filter taps is directly related to the sampling frequency. To implement (6) with a sampling period T_s of 100 μs, we will need an FIR filter by using 200 taps. For example, the frequency plots of the FIR filter (6) tuned for the fifth and the seventh harmonics ($N_h = 5,7$) and implemented with $N = 200$ taps are shown in Fig. 8.

The implementation of the original repetitive controller [22] requires a high number of the filter taps that are necessary for the chosen sampling frequency of 10 kHz. To reduce the taps number, a modified repetitive controller is proposed in this paper. The proposed filter coefficients are computed by using

$$F_{\mathrm{DFT}}(z) = \frac{2}{N}\sum_{i=0}^{N-1}\left(\sum_{k\in N_h}\cos\left(\frac{\pi}{N}h(i+N_a)\right)\right)z^{-i}. \quad (7)$$

With respect to (6), the proposed filter (7) allows halving the number of taps for the same sampling frequency. For a sampling frequency of 10 kHz, (7) will lead to $N = 100$ taps with respect to $N = 200$ taps imposed by (6), making the proposed filter more suitable for DSP implementation since the computational time will be significantly reduced.

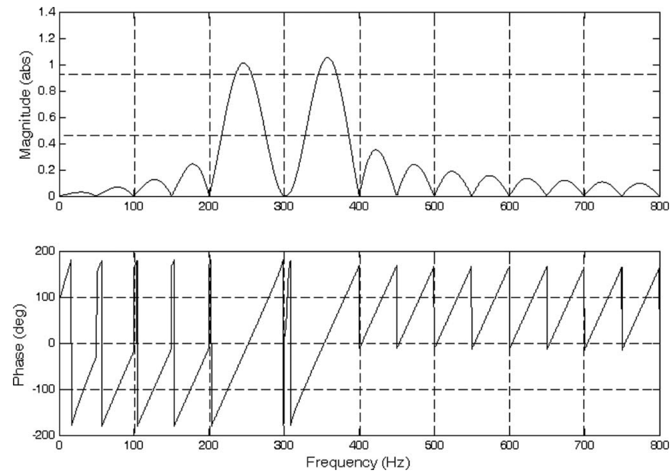

Fig. 8. DFT frequency response using $N_h = \{5,7\}$ and $N = 200$ taps.

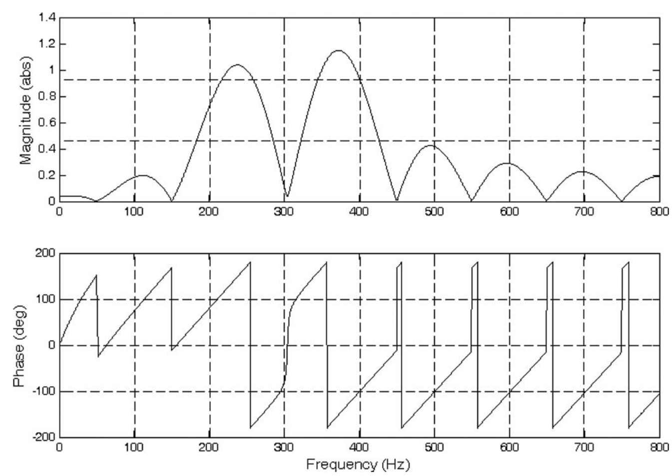

Fig. 9. DFT frequency response of the modified FIR filter using $N_h = \{5,7\}$ for $N = 100$.

The frequency plots of the proposed FIR filter (7) tuned for the fifth and the seventh harmonics ($N_h = 5$ and 7) and implemented with $N = 100$ taps are shown in Fig. 9. As can be noted from Fig. 9, the proposed FIR filter exhibits similar filtering properties with the original filter presented in [22], but the implementation is simpler due to the halved number of taps. For this reason, the current control scheme used for the experimental tests is based on the modified repetitive controller implemented with (7). The number of the leading steps N_a has been set equal to 2 since a mean delay time of 1.5 T_s is introduced by the current control loop, while the k_R parameter has been set equal to 1.

The PI controller in Fig. 7 has been designed to get a bandwidth of about 700 Hz and a phase margin of 60 electrical degrees.

III. Experimental Results

The general diagram of the experimental setup is shown in Fig. 10, where the positive polarities for grid current i_S, load current i_L, and inverter current i_F are emphasized, in agreement with Fig. 1. A general view of the experimental test bench is

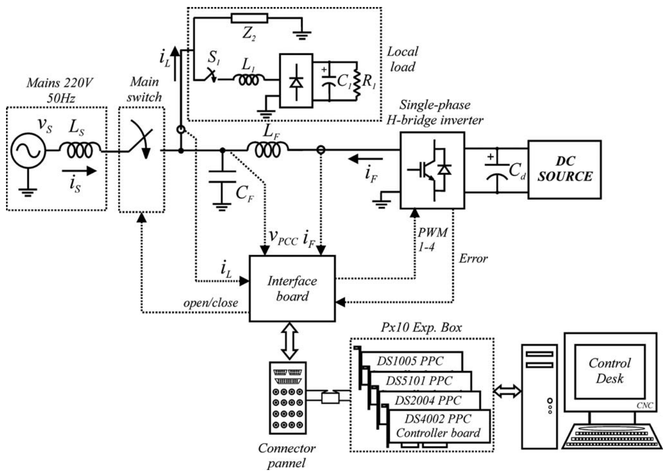

Fig. 10. Experiment setup of the single-phase inverter.

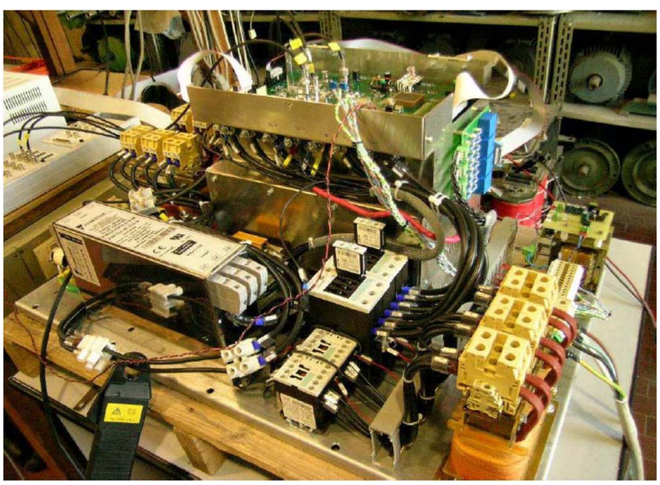

Fig. 11. General view of the experimental test bench.

TABLE I
EXPERIMENTAL SETUP PARAMETERS

Parameter	Symbol	Value
Mains voltage	v_S	220 V
Interface capacitance	C_F	7.5 µF
Interface inductance	L_F	700 µH
DC-link capacitance	C_d	2.2 mF
DC-link voltage setpoint	V_{dc}	400 V
Switching/Sampling frequency	f_{sw}, f_s	10 kHz
Fundamental frequency	f_1	50 Hz
Linear load resistance	R_2	25 Ω
Linear load inductance	L_2	30 mH
Nonlinear load input inductance	L_1	900 µH
Nonlinear load output capacitance	C_1	1 mF
Nonlinear load output resistance	R_1	50 Ω

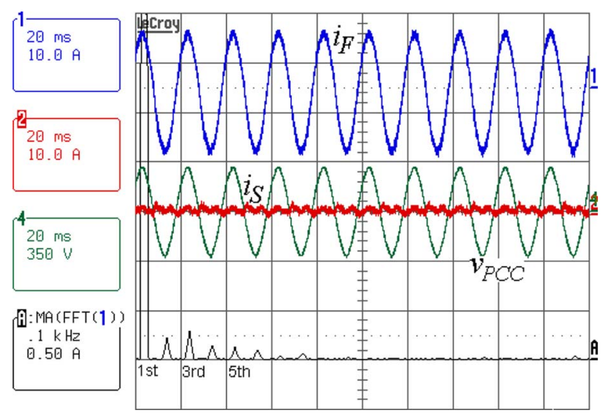

Fig. 12. Steady-state operation of the inverter injecting the active power requested by the resistive load (2 kW). (Trace 1) Inverter current i_F (10 A/div). (Trace 2) Grid current i_S (10 A/div). (Trace 4) Grid voltage v_{PCC} (350 V/div). (Trace A) Fourier analysis of the inverter current (0.5 A/div).

presented in Fig. 11 and the system parameters are given in Table I. A 4-kVA single-phase full-bridge inverter prototype using a switching frequency of 10 kHz has been used for the experimental tests.

The hardware platform used to implement the inverter control algorithm is a dSPACE development modular system based on the DS1005 processor board and several boards for each special hardware task (for example, DS 5101 board for pulse width modulation (PWM) generation, DS 2004 board for A/D conversion, and DS 4002 board for digital I/O). All boards are hosted in a dSpace PX10 expansion box that uses the DS817 board for bidirectional communication with PC through optical fibers.

The repetitive current controller parameters are $k_R = 1$, $N = 100$ (sampling frequency = 10 kHz), $N_h = 2n-1$ with $n = 1,\ldots,13$, and $N_a = 2$. The PI current controller parameters are $k_p = 3$ and $k_i = 500$.

The quantities measured from the system are the inverter current i_F, the PCC voltage $v_{\rm PCC}$, and the local load current i_L, as shown in Fig. 10. As the paper focus is on the grid-connected inverter, the dc energy source has been emulated with a three-phase diode rectifier fed by a three-phase variance.

The single-phase inverter injects active power into the grid and compensates the harmonics generated by a local load, which contains two parts: a 2-kW linear load and a 3-kVA nonlinear capacitive load (a single-phase diode rectifier with capacitive dc load). The linear load (Z_2 in Fig. 10) has been considered in the experimental tests either as a single resistance (R_2) or as a series *RL* load (R_2, L_2), whose values are specified in Table I.

The experimental tests have been performed for the following operating conditions:

1) active power generation;
2) active power generation and current harmonics compensation; and
3) reactive power compensation.

A. Validation of Active Power Generation

This test has been performed with the inverter having only a 2-kW resistive local load. The steady-state operation for the inverter, injecting 2 kW of active power, is shown in Fig. 12. In this case, it can be seen that the grid current i_S is almost zero because the local load power request is completely supplied by the inverter ($i_S = i_L - i_F$ in Fig. 10).

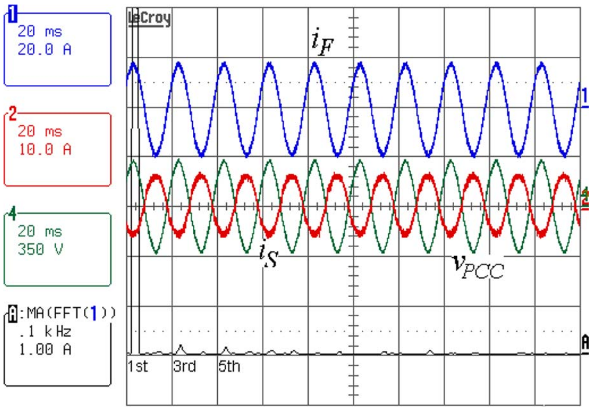

Fig. 13. Steady-state operation for 3 kW active power generation. Only the 2 kW linear load is connected in this case. (Trace 1) Inverter current i_F (20 A/div). (Trace 2) Grid current i_S (10 A/div). (Trace 4) Grid voltage $v_{\rm PCC}$ (350 V/div). (Trace A) Fourier analysis of the inverter current (0.5 A/div).

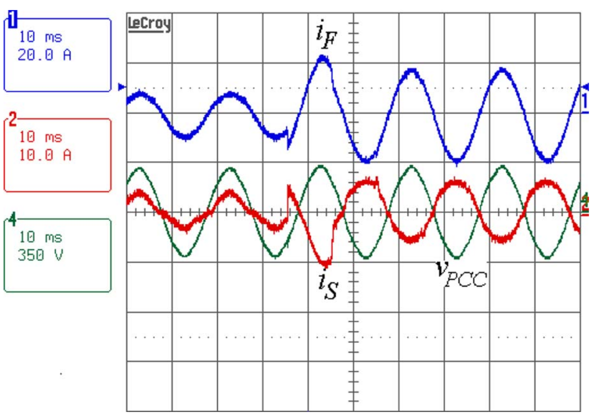

Fig. 14. Inverter transient response during a step-up of the injected active power (1–3 kW). Only the 2 kW linear load is connected. (Trace 1) Inverter current i_F (20 A/div). (Trace 2) Grid current i_S (10 A/div). (Trace 4) Grid voltage $v_{\rm PCC}$ (350 V/div).

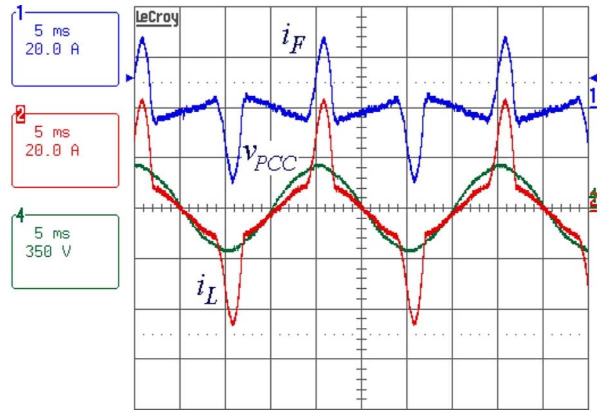

Fig. 15. Steady-state operation of the inverter injecting 1 kW active power and compensating the current harmonics of the local load. (Trace 1) Inverter current i_F (20 A/div). (Trace 2) Load current i_L (20 A/div). (Trace 4) Grid voltage $v_{\rm PCC}$ (350 V/div).

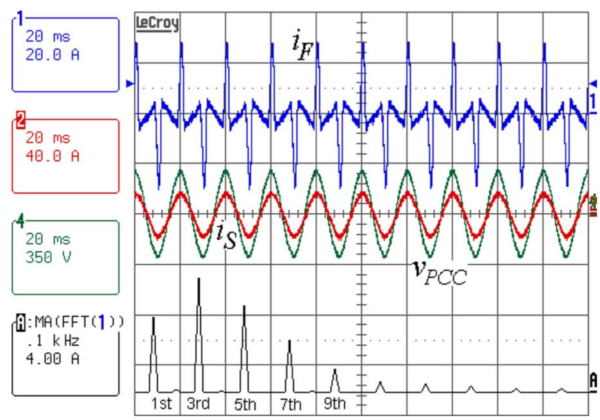

Fig. 16. Steady-state operation of the inverter injecting 1 kW active power and compensating the current harmonics of the local load. (Trace 1) Inverter current i_F (20 A/div). (Trace 2) Grid current i_S (40 A/div). (Trace 4) Grid voltage $v_{\rm PCC}$ (350 V/div). (Trace A) Fourier analysis of the inverter current (0.5 A/div).

The steady-state operation of the inverter, injecting 3 kW of active power, is presented in Fig. 13. It can be seen that the grid current is out of phase with respect to the PCC voltage by 180 electrical degrees, which means active power generation. The inverter current waveform and its Fourier analysis that are also illustrated in Fig. 13 show that the injected current is almost sinusoidal. The grid current total harmonic distortion (THD) value was about 2%.

The inverter transient response during a step-up of the injected active power reference from 1 to 3 kW is shown in Fig. 14, and the results indicate a good transient performance of the inverter control.

Before the transient, the inverter-delivered active power (1 kW) was less than the power required by the local load (2 kW), so additional power is absorbed from the grid. After the active power reference step-up transient from 1 to 3 kW, the inverter supplies the active power requested by the local load and the remaining power is injected into the grid.

B. Validation of Current Harmonics Compensation

This test has been performed with the inverter having a local load consisted of the resistance R_2 and the diode rectifier. The steady-state operation of the inverter, injecting 1 kW of active power and compensating the current harmonics of the local load, is shown in Figs. 15 and 16. The inverter current i_F, the PCC voltage $v_{\rm PCC}$, and the local load current i_L are shown in Fig. 15, while Fig. 16 contains the inverter current i_F, the PCC voltage $v_{\rm PCC}$, the grid current i_S, and the Fourier analysis of the inverter current i_F. It can be seen from Figs. 15 and 16 that even if the local load current is highly distorted, the mains current is almost sinusoidal.

Also, it can be noted that the grid current is in phase with the PCC voltage, so in this case, the local load still draws active power from the grid. This happens because the inverter-injected active power of 1 kW is smaller than the active power requested by the local load.

The inverter dynamic performance has been evaluated by turning on the load diode rectifier, as shown in Figs. 17 and 18.

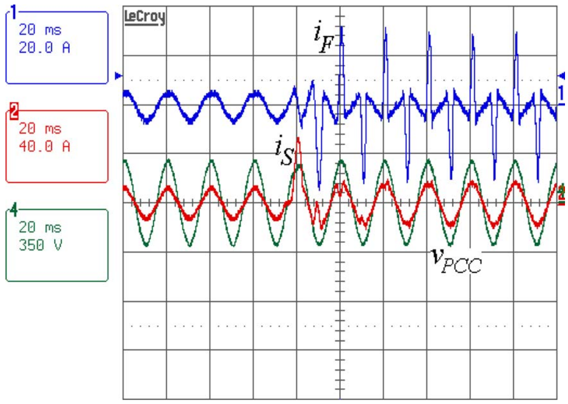

Fig. 17. Inverter transient response during nonlinear load turn-on. (Trace 1) Inverter current i_F (20 A/div). (Trace 2) Grid current i_S (40 A/div). (Trace 4) Grid voltage v_{PCC} (350 V/div).

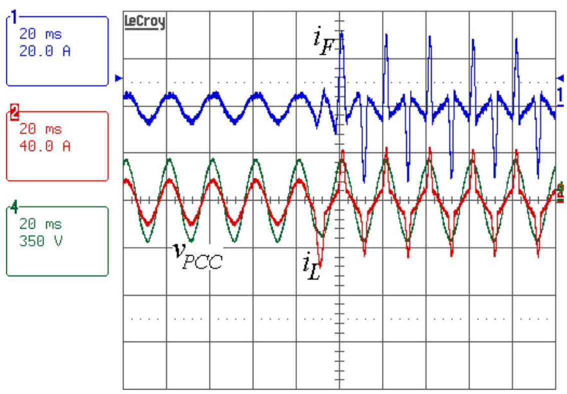

Fig. 18. Inverter transient response for nonlinear load turn-on. (Trace 1) Inverter current i_F (20 A/div). (Trace 2) Load current i_L (40 A/div). (Trace 4) Grid voltage v_{PCC} (350 V/div).

It is resulted from these figures a fast transient response of the inverter with a settling time of about 20 ms.

C. Validation of Reactive Power Compensation

To clearly emphasize the inverter capability to compensate the local load reactive power, the inverter has been operated only with an *RL* load obtained as the series connection between the resistance R_2 and the inductance L_2 (Table I). The load current lags the load voltage by about 20 electrical degrees, as shown in Fig. 19.

The inverter transient operation obtained for zero active power generation when the reactive power is enabled in a step fashion is shown in Fig. 20. It can be noted how the grid current becomes pure active since the inverter completely compensates the local load reactive power. As expected, the inverter current i_F is pure reactive and leads the PCC voltage by 90 electrical degrees (see Fig. 20).

The steady-state operation of the inverter, injecting 3 kW of active power and compensating the entire load reactive power, is shown in Fig. 21. The grid current is out of phase with respect to the PCC voltage by 180 electrical degrees, which means active power generation since the inverter generates more active power than the active power requested by the load.

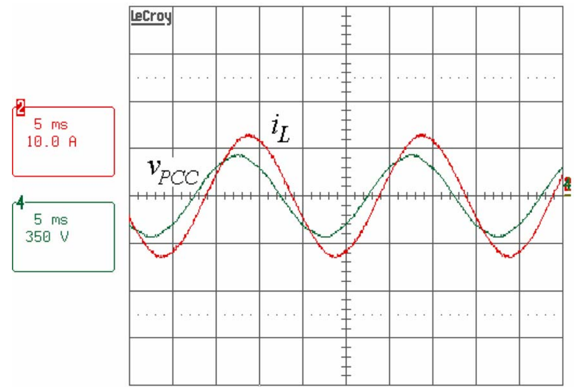

Fig. 19. Steady-state linear resistive–inductive load operation. (Trace 2) Load current i_L (10 A/div). (Trace 4) Grid voltage v_{PCC} (350 V/div).

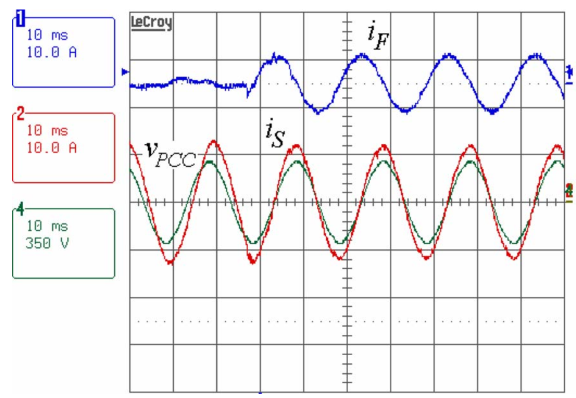

Fig. 20. Inverter transient response when only the reactive power compensation is enabled and the load is resistive–inductive. (Trace 1) Inverter current i_F (10 A/div). (Trace 2) Grid current i_S (10 A/div). (Trace 4) Grid voltage v_{PCC} (350 V/div).

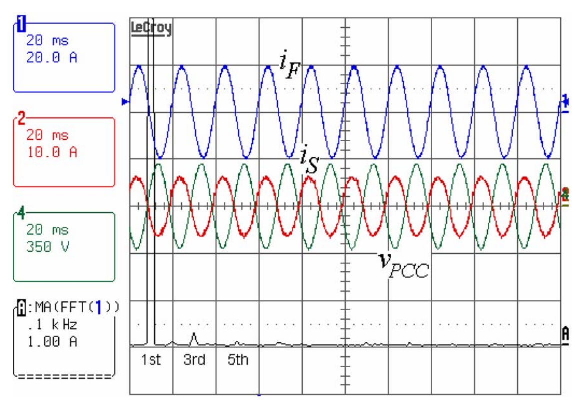

Fig. 21. Steady-state operation for 3 kW active power generation with reactive power compensation. (Trace 1) Inverter current i_F (20 A/div). (Trace 2) Grid current i_S (10 A/div). (Trace 4) Grid voltage v_{PCC} (350 V/div). (Trace A) Fourier analysis of the inverter current (0.5 A/div).

Finally, the transient response for step reactive power compensation when the generated active power was 3 kW is illustrated in Fig. 22, showing a time response of less than one grid period and no particular problems during the transient.

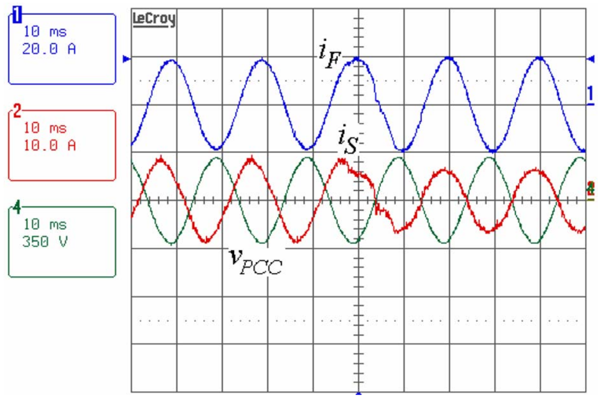

Fig. 22. Inverter transient response for step reactive power compensation when the injected active power is 3 kW. (Trace 1) Inverter current i_F (20 A/div). (Trace 2) Grid current i_S (10 V/div). (Trace 4) Grid voltage v_{PCC} (350 V/div).

IV. Conclusion

This paper deals with a single-phase H-bridge 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 H-bridge inverter injects active power into the grid and is able to compensate the local load reactive power and also the local load current harmonics.

Experimental results have been obtained on a 4-kVA inverter prototype tested for different operating conditions, including active power generation, load reactive power compensation, and load current harmonic compensation. The experimental results have shown good transient and steady-state performance in terms of grid current THD and transient response.

The integration of power quality features has the drawback that the inverter will also deliver the harmonic compensation current with the direct consequence of increase the inverter overall current and cost. A current limitation strategy should be implemented and if the inverter output current exceeds the switch rating, then the supplied harmonic current must be reduced. In this way, the inverter available current is mainly used for active power injection and if there is some current margin, this can be used for the compensation of reactive power and nonlinear load current harmonics. An analysis of the inverter design that takes into account the current required for reactive power and current harmonics compensation is beyond the paper scope and it will be subject of future study.

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