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Grid Voltage and Grid Current Harmonic Compensation Using Dual Interfacing Converters

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ABSTRACT

The Growing Installation of Distributed Generation (DG) units in low voltage distribution systems has popularized the concept of nonlinear load harmonic current compensation using multi-functional DG interfacing converters. It is analyzed in this paper that the compensation of local load harmonic current using a single DG interfacing converter may cause the amplification of supply voltage harmonics to sensitive loads, particularly when the main grid voltage is highly distorted. To address this limitation, unlike the operation of conventional unified power quality conditioners (UPQC) with series converter, a new simultaneous supply voltage and grid current harmonic compensation strategy is proposed using coordinated control of two shunt interfacing converters. Specifically, the first converter is responsible for local load supply voltage harmonic suppression.

The second converter is used to mitigate the harmonic current produced by the interaction between the first interfacing converter and the local nonlinear load. To realize a simple control of parallel converters, a modified hybrid voltage and current controller is also developed in the paper. By using this proposed controller, the grid voltage phase-locked loop and the detection of the load current and the supply voltage harmonics are unnecessary for both interfacing converters. Thus, the computational load of interfacing converters can be significantly reduced.

Simulated and experimental results are captured to validate the performance of the proposed topology and the control strategy.

INTRODUCTION

Modern electric power systems are complex networks with hundreds of generating stations and thousands of load centers are interconnected through long power transmission and distribution networks. Power quality is major concern in industries today because of enormous losses in energy and money. With the advent of myriad sophisticated electrical and electronic equipment, such as computers, programmable logic controllers and variable speed drives which are very sensitive to disturbances and non-linear loads at distribution systems produces many power quality problems like voltage sags, swells and harmonics and the purity of sine waveform is lost. Voltage sags are considered to be one of the most severe disturbances to the industrial equipments [1-3].

Power quality problems are associated with an extensive number of electromagnetic phenomena in power systems with broad ranges of time frames such as long duration variations, short duration variations and other disturbances. Short duration variations are mainly caused by either fault conditions or energization of large loads that require high starting currents. Depending on the electrical distance related to impedance type of grounding and connection of transformers between the faulted/load location and the node, there can be a temporary loss of voltage or temporary voltage reduction (sag) or voltage rise (swell) at different nodes of the system [4-6].

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POWER QUALITY

Power quality is the concept of powering and grounding sensitive equipment in a matter that is suitable to the operation of that equipment according to IEEE Std 1100. Various sources use the term “power quality” with different meanings. Other sources use similar but slightly different terminology like “quality of power supply” or “voltage quality”.

Need for power quality is:

- Equipment has become more sensitive to voltage disturbances.
- Equipment causes voltage disturbances.
- Utilities want to deliver good product.

Power Quality phenomena

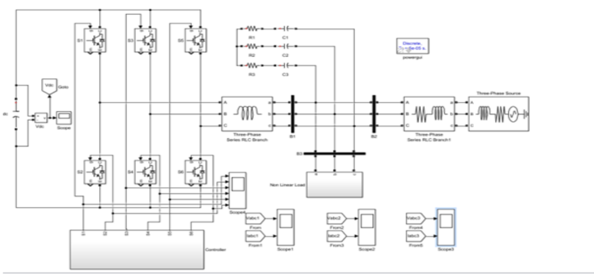
Power quality is concerned with deviations of the voltage from its ideal waveform (voltage quality) and deviations of the current from its ideal waveform (current quality). Such a deviation is called a “power quality phenomenon” or a “power quality disturbance”. Power quality phenomena can be divided into two types, they are A characteristic of voltage or current (e.g., frequency or power factor) is never exactly equal to its nominal or desired value. The small deviations from the nominal or desired value are called “voltage variations” or “current variations”. A property of any variation is that it has a value at any moment in time, e.g., the frequency is never exactly equal to 50 Hz or 60 Hz; the power factor is never exactly unity. Monitoring of a variation thus has to take place continuously [7-9].

RESULTS

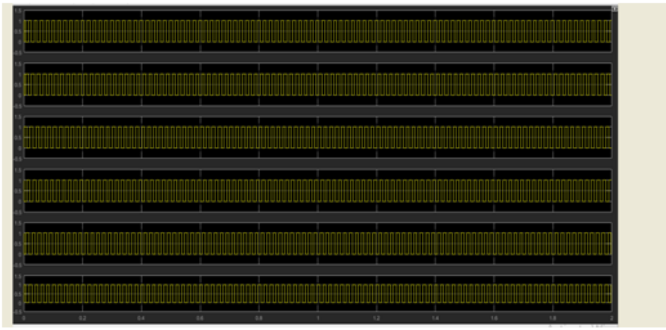
The proposed method is also verified on a voltage-scaled laboratory DG test rig with two parallel interfacing converters at the same power rating. The detailed circuit and control parameters can be seen from Table I and the configuration of the system is illustrated.First, only converter1 with the supply voltage harmonic mitigation as the control objective is connected to a highly distorted grid. The converter2 is disconnected from the grid in order to clearly show the characteristics of converter1. The corresponding performance of the system are shown.The grid voltage waveform with 7.5% THD is shown . The local load in this case is a diode rectifier with the distorted current as shown. Note that the distorted grid voltage and local load are used for the verification of grid current compensation and simultaneously compensation using dual-converter. As the directly supply voltage harmonic control is achieved by the second term of the controller as shown, it can be noticed that the supply voltage is very smooth with only 2.01% THD. At the same time, due to a fact that the ripple-free supply voltage and the highly distorted grid voltage are interconnected with converter1 output filter choke $_1$, it can be seen that both the grid current and the converter1 line current in this case have significant harmonic distortions as shown , respectively shows the power response when the active power reference increases from 0 kW to 5kW and the reactive power reference increases from 0 kVar to 5kVar. As shown, the power control reaches a steady-state for around 0.1 sec after the change of the references. In addition, it can be observed that the steady-state power control error is zero even when the supply voltage compensation is activated in the DG system [10].

In addition, when only converter2 is applied to compensate the nonlinear load harmonics and the converter1 is disconnected from the grid, the corresponding performance of the system is obtained Similarly, the grid voltage is also distorted and the diode rectifier load is placed at the output of converter2. However, in contrast to the counterpart it can be clearly seen that the supply voltage to the local load is highly distorted in with 7.3% THD. This is because the harmonic current from the local load is compensated by converter2. Thus, the three-phase grid current in this case is sinusoidal with only 4.08% as illustrated. Nevertheless, since the harmonic current from the nonlinear flow to the converter2, the converter2 line current in this case has nontrivial harmonic current.Similar to the previous test, the response to a step increase of real and reactive power reference.The power control characteristics are similar to the counterpart. This is because the Power Control term is very well decoupled from the Harmonic Compensation term in the proposed control method.Up to now, the conclusion that a single shunt interfacing converter can hardly maintain improved supply voltage and grid current quality at the same time has been verified by the experimental results .When both converter1 and converter2 are connected to the experimental system to achieve simultaneous harmonic supply voltage and harmonic grid current mitigation, the corresponding Similar to the previous two experiments, the grid voltage in this case is highly distorted and a nonlinear load is connected to the shunt capacitor of converter1.Since converter1 is used to compensate the harmonic voltage at the local load connection point, the line current is distorted. As the harmonic current caused by the interactions between the local nonlinear load and the converter1 is compensated by the line current control of converter2, it can be seen from that the line current of converter2 also contains significant harmonics. Due to the coordinated operation of both converter1 and converter2, the enhanced supply voltage and grid current quality is realized respectively. The corresponding THDs of the supply voltage and the grid current are 2.25% and 3.59%, respectively. Note that during the entire process, no PLLs or harmonic extraction is involved in the control schemes.Finally, the power response of this dual-converter system is shown. Due to the involvement of dual converters, the power reference for each converter is a half of that . Due to the decoupled feature of the proposed method, two converters have similar response in this case and the steady-state tracking error is zero for both converters.

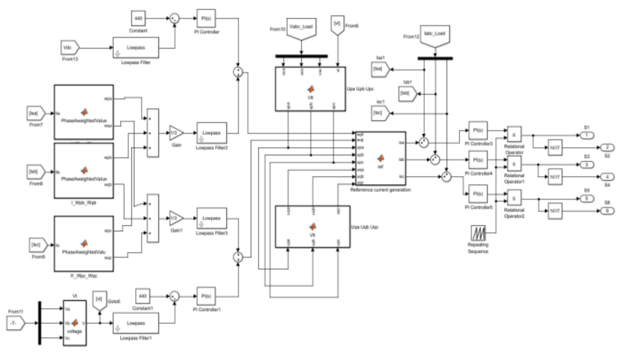
MATLAB RESULTS



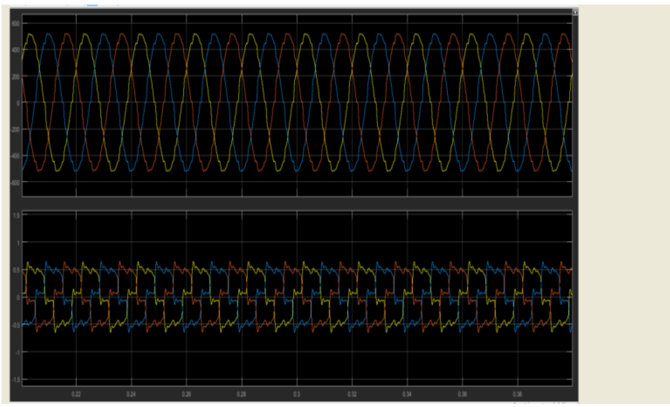
Simuation Diagram



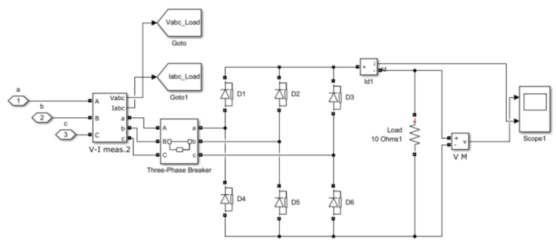
Waveform



Matlab Simulation



Matlab Waveform



Matlab Simulation

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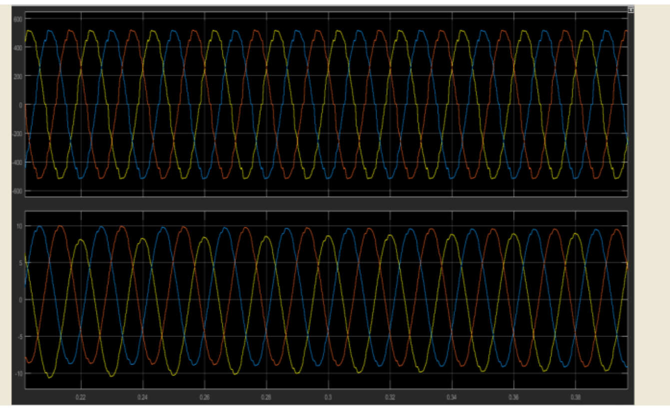

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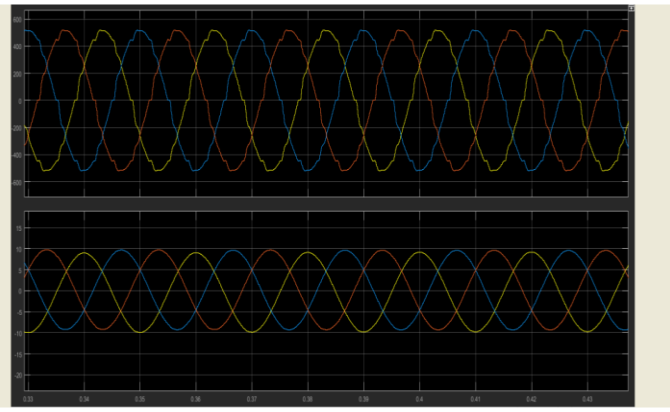

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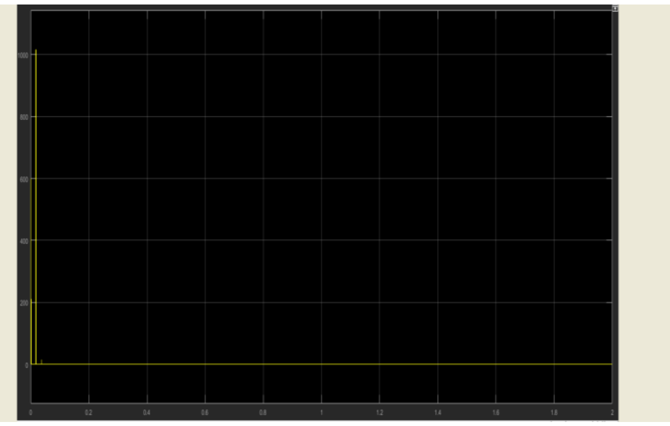

Matlab Waveform

CONCLUSION

When a single multi-functional interfacing converter is adopted to compensate the harmonic current from local nonlinear loads, the quality of supply voltage to local load can hardly be improved at the same time, particular when the main grid voltage is distorted. This paper discusses a novel coordinated voltage and current controller for dual-converter system in which the local load is directly connected to the shunt capacitor of the first converter. With the configuration, the quality of supply voltage can be enhanced via a direct closed-loop harmonic voltage control of filter capacitor voltage. At the same time, the harmonic current caused by the nonlinear load and the first converter is compensated by thesecond converter. Thus, the quality of the grid current and the supply voltage are both significantly improved. To reduce the computational load of DG interfacing converter, the coordinated voltage and current control without using load current/supply voltage harmonic extractions or phase-lock loops is developed to realize to coordinated control of parallel converters

FUTURE SCOPE

In this project we are using Pi controller in place that we use fuzzy logic controller or ANFIS controller to overcome conventional controller drawbacks.

REFERENCES

[1]. B. Singh, K. AI-Haddad, A. Chandra, “A review of active filters for power quality improvement,” IEEE Trans. Ind.Electron., vol. 46, no. 5, pp. 960 - 971, May. 1999.

[2]. P. Acuna, L. Moran, M. Rivera, J. Dixon, and J. Rodriguez, “Improved active power filter performance for renewable power generation systems,” IEEE Trans. Power Electron., vol. 29, no.2, pp. 687-694, Feb. 2013.

[3]. Y. W. Li, F. Blaabjerg, D. M. Vilathgamuwa, and P. C. Loh,“Design and Comparison of High Performance Stationary-Frame Controllers for DVR Implementation,” IEEETrans. Power Electron., vol. 22, pp. 602-612, Mar. 2007.

[4]. C. Meyer, R. W. DeDoncker, Y. W. Li, and F. Blaabjerg, “Optimized Control Strategy for a Medium-Voltage DVR – Theoretical Investigations and

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International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Experimental Results," IEEETrans. Power Electron., vol. 23, pp. 2746-2754, Nov. 2008.

[5]. F. Blaabjerg, Z. Chen, and S. B. Kjaer, "Power electronics as efficient interface in dispersed power generation systems,"IEEE Trans. Power Electron., vol. 19, pp. 1184-1194, Sep.2004.

[6]. A. Timbus, M. Liserre, R. Teodorescu, P. Rodriguez, and F. Blaabjerg, "Evaluation of current controllers for distributedpower generation systems," IEEE Trans. Power Electron., vol. 24, no. 3, pp. 654–664, Mar. 2009.

[7]. J. M. Guerrero, L. G. Vicuna, J. Matas, M. Castilla, and J.Miret, "A wireless controller to enhance dynamic performance of parallel inverters in distributed generation systems," IEEETrans. Power Electron., vol. 19, no. 4, pp. 1205-1213, Sep,2004.

[8]. J. M. Guerrero, J. C. Vasquez, J. Matas, L.G. de Vicuna, and M. Castilla, "Hierarchical control of droop-controlled AC and DC microgrids - A general approach toward standardization," IEEETrans. Ind. Electron., vol. 55, no. 1, pp. 158 - 172, Jan. 2011.

[9]. J. He and Y. W. Li, "Analysis, design and implementation of virtual impedance for power electronics interfaced distributed generation," IEEE Trans. Ind. Applicat., vol. 47, no. 6, pp. 2525-2038, Nov/Dec. 2011.

[10]. Q. Zhang, "Robust droop controller for accurate proportional load sharing among inverters operated in parallel," IEEE Trans.Ind. Electron., vol. 60, no. 4, pp. 1281–1290, Apr. 2013.

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