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Paper Authors

*** SADIVELA KARUNAKAR, T.NIRANJAN.**

* Dept of EEE, Tudi Ramreddy Institute of Science and Technology.

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COMPENSATION OF MICROGRID VOLTAGE AND CURRENT HARMONICS BY EMPLOYING COORDINATED MANAGEMENT DUAL INTERFACING CONVERTERS

***SADIVELA KARUNAKAR, **T.NIRANJAN**
*PG Scholar, Dept of EEE, Tudi Ramreddy Institute of Scinece and Technology
**Assistant Professor, Dept of EEE, Tudi Ramreddy Institute of Scinece and Technology

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

There are growing demands of using power conditioning circuits in low and medium voltage power distribution system. Comparing to bulky passive filters that are highly sensitive to circuit parameters variations, the active power conditioning equipment including active power filter (APF), dynamic voltage restorer (DVR), and unified power quality conditioner (UPQC) is preferred due the fast dynamic response and the good immunity to system parameter changes. On the other hand, the high penetration of distributed generation (DG) unit with power electronics interfacing converter offers the possibility of power distribution system harmonic current compensation using multi-functional DG interfacing converter.

Previous research mainly focused on the control of a single DG shunt interfacing converter as an APF, as their power electronics circuits have similar topology. To realize an enhanced active filtering objective, the conventional current control methods for grid-tied DG interfacing converter shall be modified. First, the wide bandwidth current controllers are used so that the frequencies of harmonic load current can fall into the bandwidth of the current controller. Alternatively, the selective frequency harmonic compensation using multi-resonant current controller has received a lot of attenuations, the deadbeat controller is developed for multiple DG units with active harmonic filtering capability. In the neural network method is used to improve the harmonic filtering performance of DG interfacing converters that are connected to a grid with large variation of grid impedance.

In addition to the compensation of harmonics at low voltage distribution networks, the active filtering of harmonics in higher voltage distribution system using multi-level converters is discussed. However, it is important

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to note that abovementioned compensation methods are mainly used in grid-tied converter systems. In recent literature, the hybrid voltage and current control is also developed to realize a fundamental voltage control for DG power regulation and a harmonic current control for local load harmonic compensation.

Compared to the aforementioned conventional current control methods, the hybrid controller allows an interfacing converter to compensate harmonics in both grid-tied and islanding micorgrids. With assistance of the low bandwidth communications between DG units, it also possible to achieve harmonic power sharing among parallel DG systems. It is worth to mention that when an interfacing converter is applied to compensate shunt loads harmonic current, developing high efficiency controller to reduce the computational load of DG system is important. To realize this task, the compensation without load harmonic current extraction becomes very attractive. In the phase-locked loop is removed by using a series current compensator, meanwhile keeping robust synchronization with the main grid. In recent literature, an enhanced current controller utilizing the frequency selective feature of resonant controllers was proposed to remove both the load current harmonic extraction and the phase-locked loop in a single-phase DG unit.

Nevertheless, it is important to emphasis that even when the local load harmonic current is properly compensated using various controllers as mentioned above, high quality supply voltage to local load cannot be guaranteed at the same time. This problem is particularly serious when the DG interfacing converter is interconnected to a weak microgrid with nontrivial upstream grid voltage distortions. To overcome this limitation, the dynamics voltage restorer (DVR) with series harmonic voltage compensation capability can be installed in the power distribution system. Unfortunately, the functionality of a DVR can hardly be implemented in a shunt DG interfacing converter. Using an additional series power conditioning equipment to ensure very low steady-state harmonic supply voltage to local loads is definitely feasible. However, it is associated with more expenses which might not be accepted for cost-effective power distribution systems.

To realize simultaneous mitigation of the grid current and the supply voltage harmonics, this paper develops a parallel-converter topology where the local nonlinear load is directly installed to the shunt filter capacitor of the first converter. The local load supply voltage quality is enhanced by the first interfacing converter through harmonic voltage control. The harmonic current produced by the interactions between the local nonlinear load and the first converter is then compensated by the second converter. To reduce the computational load of the dual-converter system, a modified hybrid voltage and current control method is proposed for parallel interfacing converters. With cooperative operation of two converters, the load current and supply voltage harmonic extraction and the phase-locked loops are not needed to realize this proposed comprehensive power quality control objective. Note that this paper focuses on the compensation of supply voltage and grid current harmonics. When there are significant disturbances in the main grids, such as sags/swells and interruptions, the shunt converter is less effective to compensate these grid issues. Thus in these cases, the protection and the fault-ride through control schemes for a conventional single converter can be applied to this dual-converter in a similar manner.

PROPOSED SYTEM

REVIEW OF CONVENTIONAL APF AND DVR

This section briefly reviews the control of shunt APFs for grid current harmonic mitigation and series DVRs for supply voltage harmonic suppression. In order to compare with the proposed parallel-converter using modified hybrid voltage and current controller as shown in the next section, the well-understood double-loop current control and voltage control are applied to APFs and DVRs, respectively.

Shunt Interfacing Converters for Grid Current Harmonic Mitigation

Fig. 1(a) shows the topology and control strategy of an interfacing converter for

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compensating harmonic current from a local nonlinear load. First, the local load is connected to the output of the interfacing converter, and then, they are coupled to the main grid through the grid feeder. The parameters of the interfacing converter LCL filter and the grid feeder are listed as $z_1(s) = sL_1 + R_1$, $z_2(s) = sL_2 + R_2$, $z_3(s) = 1/(sC_f)$, and $z_g(s) = sL_g + R_g$, where L_1, L_2, R_1, and R_2 are the inductance and resistance of the filter

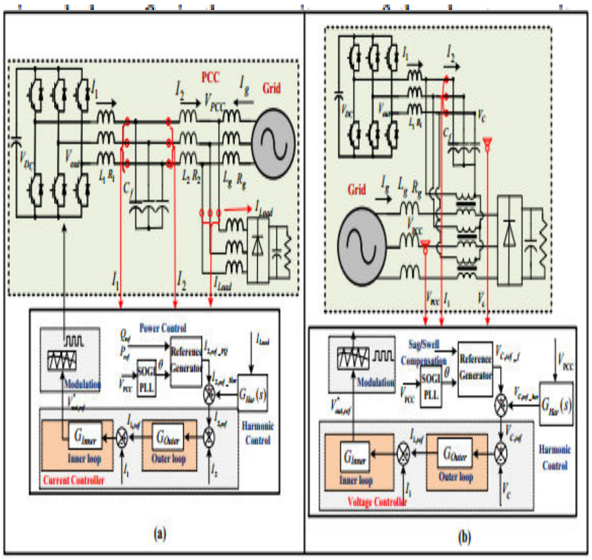

Fig. 1. Diagram of local harmonic compensation using interfacing converter.

The current control scheme is shown in the lower part of Fig. 1(a). According to the traditional APF control theory, the local load current is measured and the harmonic components are detected as:

$$I_{2,ref\_h} = H_{Har}(s) \cdot I_{Load}$$

THE PROPOSED COORDINATED CONTROL METHOD

To have simultaneous mitigation of the supply voltage and the grid current harmonics, a compensation method using coordinated control of two parallel interfacing converters is proposed in this section. The circuitry and control diagrams of the proposed system are shown in Fig. 2 and Fig. 3, respectively. First, a DG unit with two parallel interfacing converters sharing the same DC rail is connected to PCC. Each interfacing converter has an output LCL filter and the local nonlinear load is placed at the output filter capacitor of converter1. In this topology, the supply voltage to local nonlinear load is enhanced by controlling the harmonic component of interfacing converter1.

Meanwhile, the grid current harmonic is mitigated via the power conditioning through interfacing converter2. Their detailed control strategies are discussed respectively, as shown below:

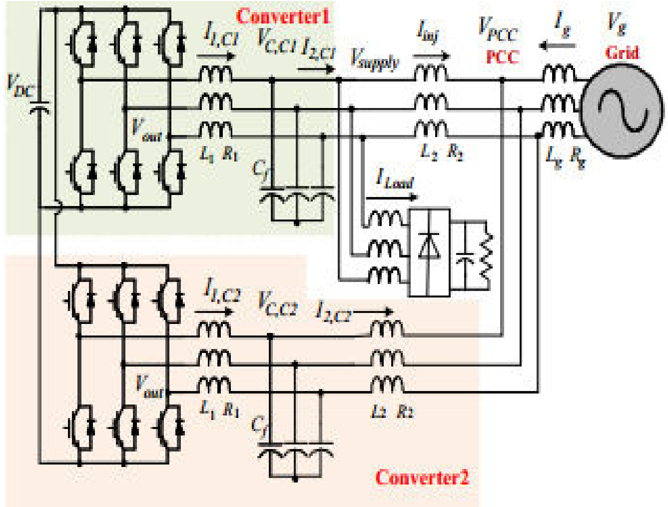

Fig. 2. Diagram of the proposed topology.

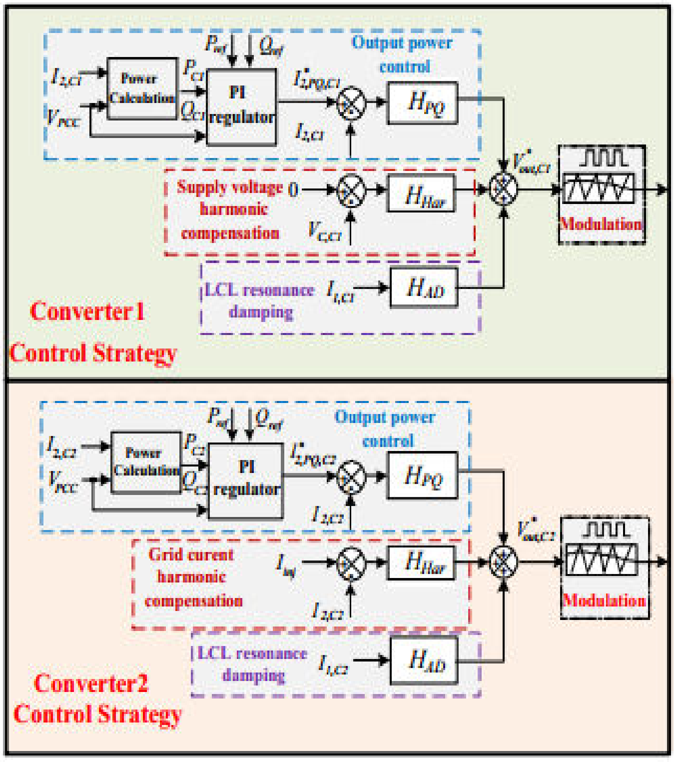

Fig. 3. Diagram of the proposed interfacing converter control strategies.

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SIMULATION RESULTS

EXISTING RESULTS

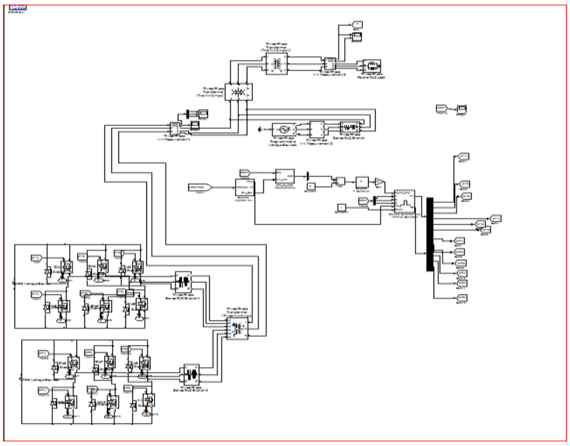

Fig 6.1 MATLAB/SIMULINK diagram of interfacing converter

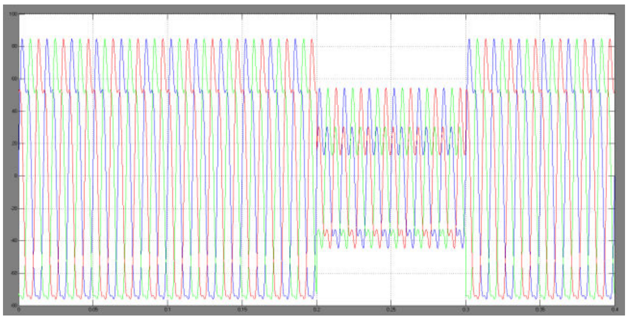

Fig 6.2 Source voltage

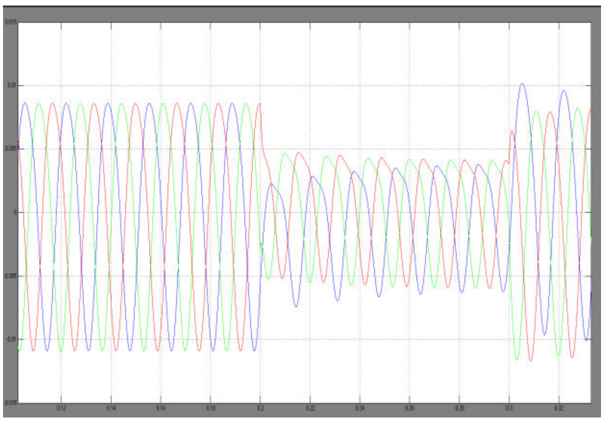

Fig 6.3 Source current

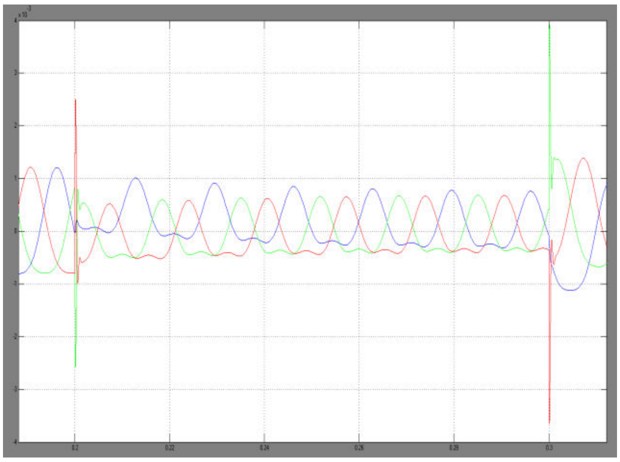

Fig 6.4 Injected current

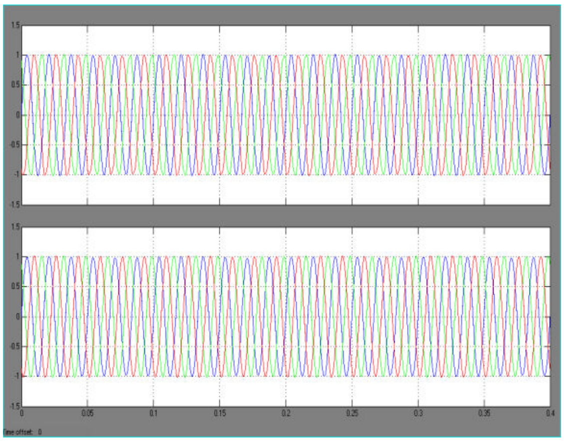

Fig 6.5 Load voltage and current

6.2 EXTENSION RESULTS

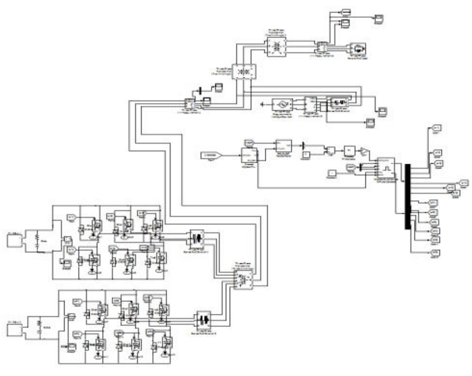

Fig 6.6 MATLAB/SIMULINK diagram of proposed pv connected interfacing converter

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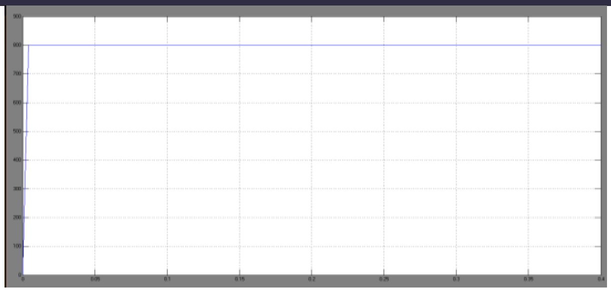

Fig 6.7 PV voltage

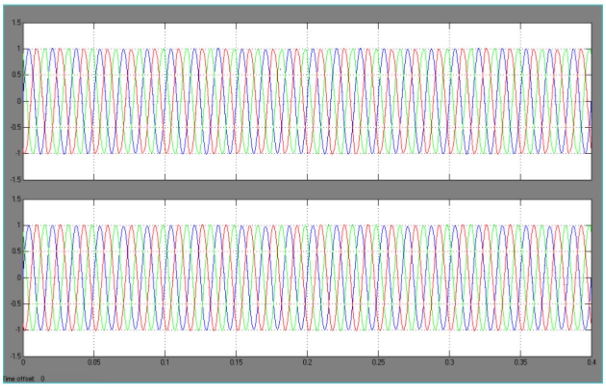

Fig 6.8 Load voltage and current

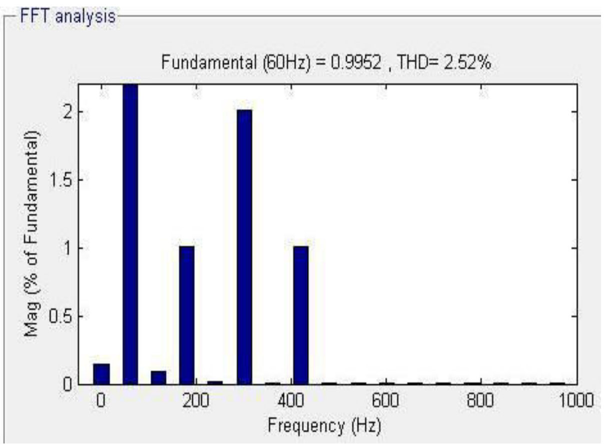

Fig 6.9 Thd of load current

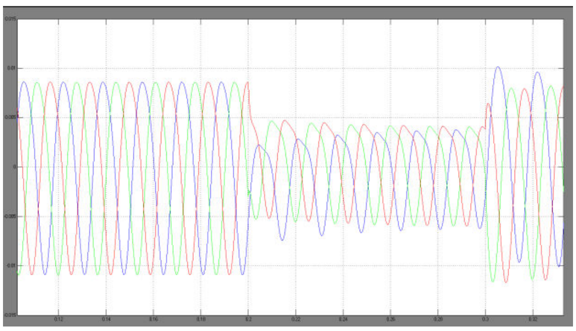

Fig 6.10 Source current

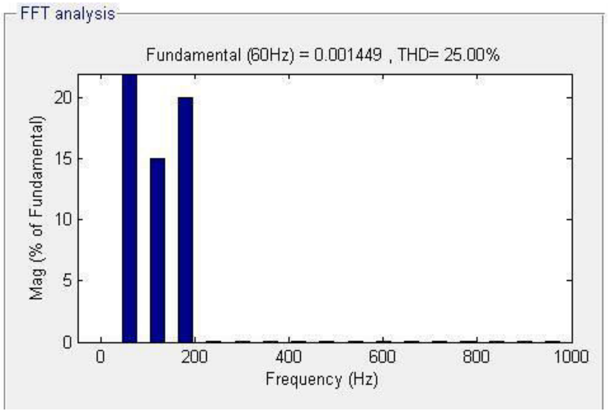

Fig 6.11 Thd at source current

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 the second 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. In extension we studied about PV connected interfacing converters

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," *IEEE Trans. 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 Experimental Results," *IEEE Trans. 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 distributed power 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," *IEEE Trans. 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," *IEEE Trans. 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.

[11] W. Issa, M. Abusara, and S. Sharkh, "Control of transient power during unintentional islanding of microgrids," *IEEE Trans. Power Electron.*, online early access.

[12] C.-L. Chen, Y. Wang, J.-S. Lai, Y.-S. Lee, D. Martin, "Design of parallel inverters for smooth mode transfer microgrid applications," *IEEE Trans. Power. Electron.*, vol. 25, no. 1, pp. 6–15, Jan. 2010.

[13] N. Pogaku and T.C. Green, "Harmonic mitigation throughout a distribution system: a distributed-generator-based solution," *IEE Proc. Gener. Transm. Distrib.*, vol.153, no.3, pp. 350-358, May. 2006.

[14] C. J. Gajanayake, D. M. Vilathgamuwa, P. C. Loh, R. Teodorescu, and F. Blaabjerg, "Z-source-inverter-based flexible distributed generation system solution for grid power quality improvement," *IEEE Trans. Energy Conversion*, vol.24, pp.695-704, Sep. 2009.

[15] R. I. Bojoi, L. R. Limongi, D. Roiu, and A. Tenconi, "Enhanced power quality control strategy for single-phase inverters in distributed generation systems," *IEEE Trans. Power Electron.,* vol. 26, no.3, pp. 798–806, Mar. 2011.