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INTELLIGENT ISLANDING AND SEAMLESS RECONNECTING TECHNIQUE FOR MICRO GRIDS WITH UPQC

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Abstract

In this paper a new proposal for the placement, integration, and control of unified power quality conditioner (UPQC) in distributed generation (DG)-based grid connected/autonomous micro grid/micro generation (µG) system has been presented. A power distribution system with distributed generations can operate as a micro grid under specific conditions. A micro grid can be operated under grid-connected and islanded modes seamlessly without disrupting the loads within the micro grid. . This study analyzes the intelligent control of a micro grid with a pulse-width modulation-controlled voltage source inverter. The DG converters (with storage) and the shunt part of the UPQC Active Power Filter (APFsh) is placed at the Point of Common Coupling (PCC). The series part of the UPQC (APFse) is connected before the PCC and in series with the grid. the voltage and frequency of a micro grid by using Matlab/Simulink environment.

Index Terms— **Distributed generation (DG), intelligent islanding detection (IsD), microgrid, power quality, smart grid, unified power quality compensator (UPQC).**

I. INTRODUCTION

The challenging issues of a successful integration of unified power quality conditioner (UPQC) in a distributed generation (DG)-based grid connected microgeneration (μG) system are primarily: 1) control complexity for active power transfer; 2) ability to compensate non active power during the islanded mode; and 3) difficulty in the capacity enhancement in a modular way [1]. For a seamless power transfer between the grid-connected operation and islanded mode, various operational changes are involved, such as switching between the current and voltage control mode, robustness against the islanding detection and reconnection delays, and so on [2], [3].Clearly, these further increase the control complexity of the μG systems. To extend the operational flexibility and to improve the power quality in grid connected μG systems, a new placement and integration technique of UPQC have been proposed in [4], which is termed as UPQCμG. In the UPQCμG integrated

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distributed system, μG system (with storage) and shunt part of the UPQC are placed at the Point of Common Coupling (PCC). The series part of the UPQC is placed before the PCC and in series with the grid. The dc link is also connected to the storage, if present. To maintain the operation in islanded mode and reconnection through the UPQC, communication process between the UPQC μG and μG system is mentioned in [4]. In this paper, the control technique of the presented UPQCμG in [4] is enhanced by implementing an intelligent islanding and novel reconnection technique with reduced number of switches that will ensure seamless operation of the μG without interruption. Fig. 1 illustrates a block diagram of the proposed micro grid system with VSI. As illustrated, this system consists of the control system and an inverter with filter that interfaces the DGs with the grid. The DGs generally used in a micro grid are photovoltaic, fuel cell, and micro turbine generators. The configuration and utilization of a set of DGs usually depend on customer needs and load criticality. The DC power sources can either be directly interfaced to the AC system through an inverter or be first set to an inverter compatible DC voltage level using a DC–DC converter and then converted into three phases using an inverter. AC power sources (e.g., micro turbines) that produce power high frequencies are first rectified and then converted to three-phase. The loads within a micro grid can either be electrical and/ or thermal in nature. They can be further classified into critical and non-critical loads. During islanding, load shedding of non-critical loads can be performed to maintain the power balance and hence stability of the micro grid system. Therefore, the critical loads can be continued to operate in a normal manner through load shedding. The control system shown in Fig. 1 consists of several sub- systems, including voltage and current control functions, grid synchronization function, and a pulse-width modulation (PWM) generator.

II . WORKING PRINCIPLE

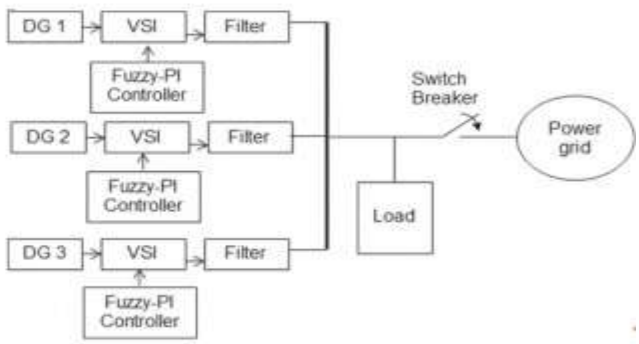


Fig.1. Block Diagram of the Micro Grid System

This paper has been organized as follows. The working principle of the proposed system is described in Section II. Based on the working principle, some of the design issues and rating selection have been discussed in Section III. Section IV deals with the islanding detection and reconnection techniques in detail. SectionV says conclusion

The integration technique of the proposed UPQC$_{\mu G-IR}$ to a grid connected and DG integrated μG system is shown in Fig. 2(a). S2 and S3 are the breaker switches that are used to island and reconnect the μG system to the grid as directed by the secondary control of the $UPQC_{\mu G-IR}$. The working principle during the interconnected and islanded mode for this configuration is shown in Fig. 1(b) and (c). The operation of $UPQC_{\mu G-IR}$ can be divided into two modes.

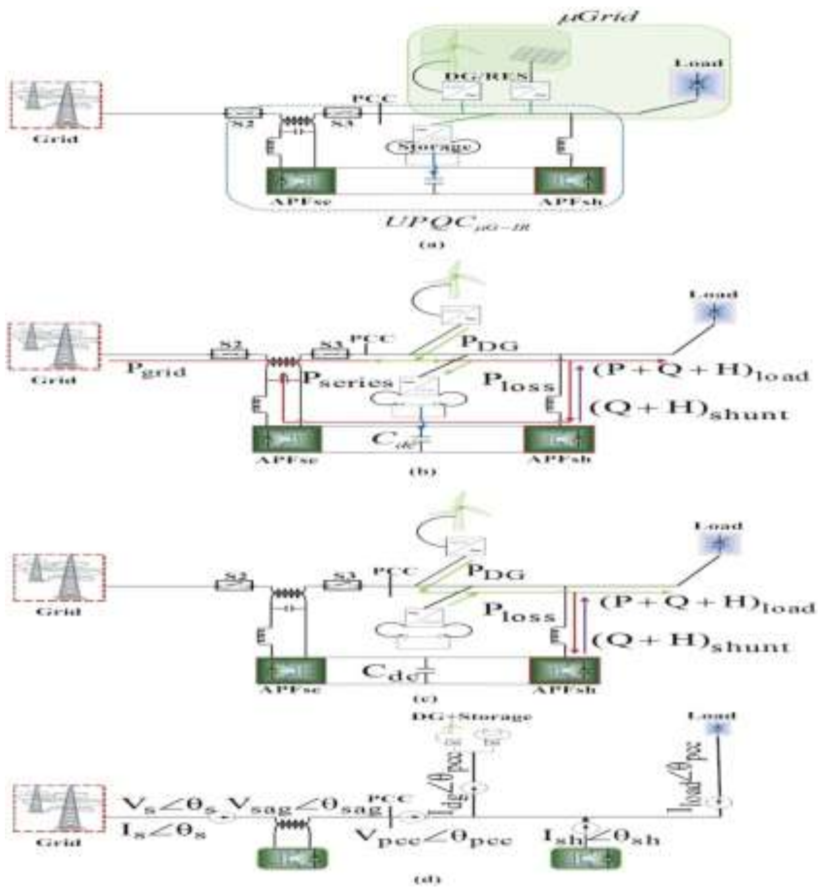


Fig. 2. (a) Integration technique of the $UPQC_{\mu G-IR}$. Working principle in (b) interconnected mode, (c) islanded mode, and (d) fundamental frequency representation.

A. INTERCONNECTED MODE

In this mode, as shown in Fig. 1(b), the following holds:

1) the DG source delivers only the fundamental active power to the grid, storage, and load;
2) the APF_{sh} compensates the reactive and harmonic (QH) power of the nonlinear load to keep the Total Harmonic Distortion at the PCC within the IEEE standard limit;
3) voltage sag/swell/interruption can be compensated by the active power from the grid/storage

through the $APF_{se,t}$. The DG converter does not sense any kind of voltage disturbance at the PCC and hence remains connected in any condition;

4) if the voltage interruption/black out occurs, UPQC sends a signal within a preset time to the DG converter to be islanded.

B. IS LANDED MODE

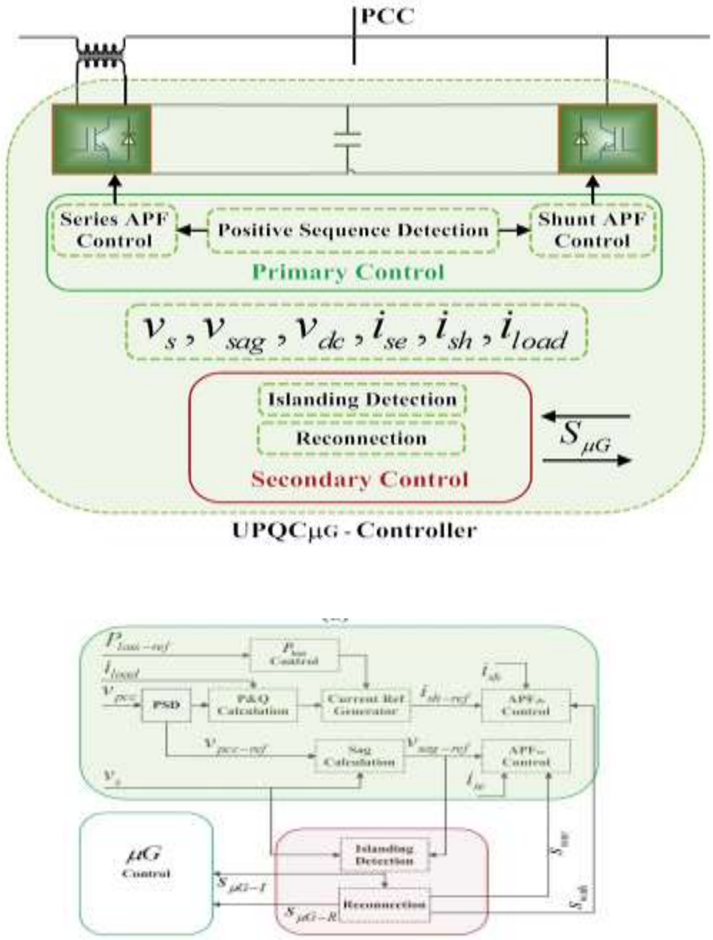
In this case, as shown in Fig. 1(c), the following holds:

1) the APF_{se} is disconnected during the grid failure and DG converter remains connected to maintain the voltage at PCC;
2) the APF_{sh} still compensates the nonactive power of the nonlinear load to provide or maintain undistorted current at PCC for other linear loads (if any);
3) therefore, DG converter (with storage) delivers only the active power and hence does not need to be disconnected from the system;
4) the APF_{se} is reconnected once the grid power is available.

From Fig. 1(a)–(c), it is clear that the $UPQC_{\mu G-IR}$ requires two switches compared with four, as required for $UPQC_{\mu G}$ in [4]. A detail of the switching mechanism is discussed in the controller design section

III. CONTROLLER DESIGN

The block diagram of the proposed $UPQC_{\mu G-IR}$ controller is shown in Fig. 4. It has the same basic functionality as the UPQC controller except for the additional islanding detection and reconnection capabilities. A communication channel (signals transfer) between the proposed $UPQC_{\mu G-IR}$ and the μG is also required for the smooth operation. These signals generation are based on the sag/swell/interrupt/supply failure conditions. This task is performed in Level 2 (secondary control) of the hierarchical control [13]. Level 1 deals with the primary control of the UPQC to perform their basic functions in the interconnected and the islanded mode [14]. The overall integration technique and control strategy are to improve the power quality during interconnected and islanded modes. This involves detecting islanding and reconnection that ensures the DG converter remains connected and supply active power to the load. This reduces the control complexity of the converter as well as the power failure possibility in the islanded mode. The five main elements of the proposed $UPQC_{\mu G-IR}$ controller are: 1) positive sequence detection; 2) series part (APF_{se}) control; 3) shunt part (APF_{sh}) control; 4) intelligent islanding detection (IsD); and 5) synchronization and reconnection (SynRec). As the IsD and SynRec features are new in UPQC, therefore, these have been described in details.



Block diagram of the UPQCμG−IR. (a) Controller. (b) Control algorithm.

IV.UNIFIED POWER QUALITY CONDITIONER

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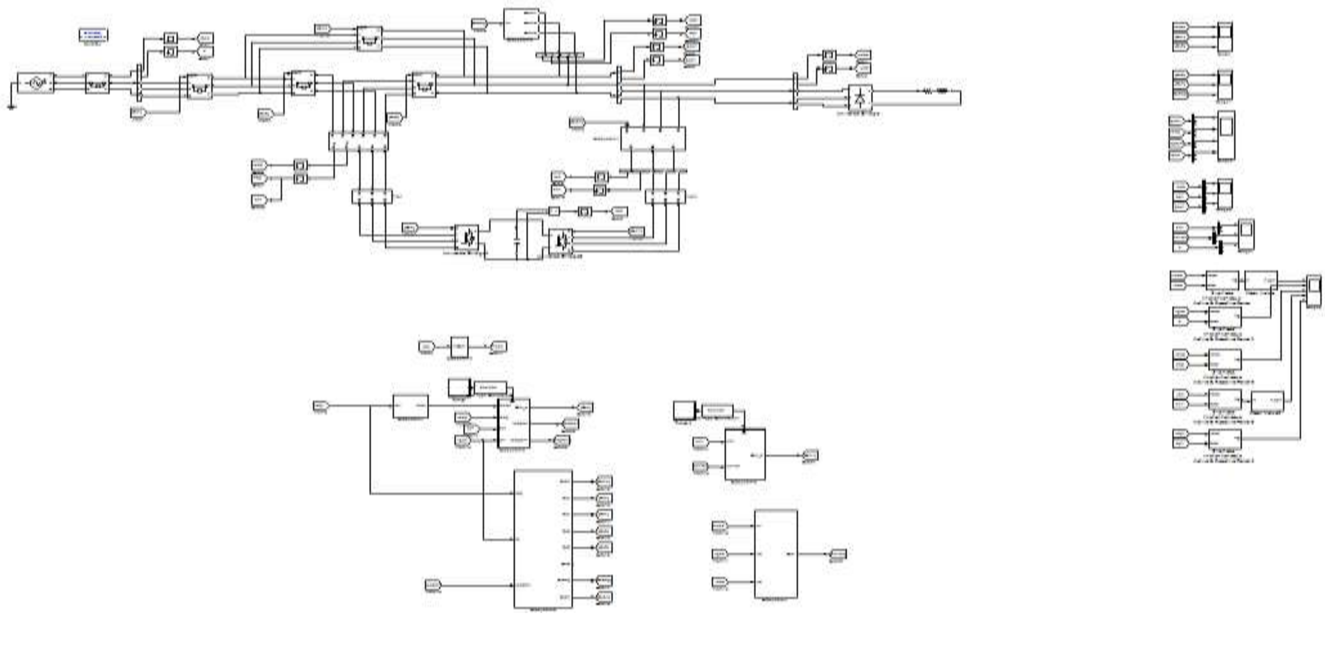
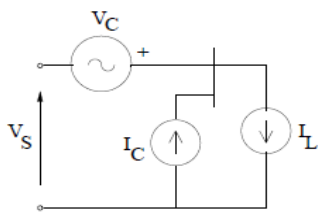


Fig1 block diagram of unified power quality conditioner

A .Operation of UPQC



The operation of a UPQC can be explained from the analysis of the idealized equivalent circuit shown in Fig. 14.16. Here, the series converter is represented by a voltage source VC and the shunt converter is represented by a current source IC. Note that all the currents and voltages are 3 dimensional vectors with phase coordinates. Unlike in the case of a UPFC (discussed in chapter 8), the voltages and currents may contain negative and zero sequence components in addition to harmonics. Neglecting losses in the converters, we get the relation

$\langle V_L, I_C \rangle \langle V_C, I_S \rangle = 0$

where X,Ydenote the inner product of two vectors, defined by

$$\langle X, Y \rangle = \frac{1}{T}\int_0^T X^t(T)Y(T)dT. \text{ --------------Eq(1)}$$

Let the load current IL and the source voltage VS be decomposed into two
Components given by

$I_L = I_L^{1p} + I_L^r$

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$V_s = V_S^{1p} + v_s^r$

Where I1p L contains only positive sequence, fundamental frequency components. Similar comments apply to V 1pS . IrL and V rS contain rest of the load current and the source voltage including harmonics. I1pL is not unique and depends on the power factor at the load bus. However, the following relation applies for I1p L .

$$P_L = \langle V_L, I_L \rangle = \langle V_L, I_L^{1p} \rangle \text{------------------Eq(2)}$$

This implies that hIrL ; VLi = 0. Thus, the fundamental frequency, positive sequence component in IrL does not contribute to the active power in the load. To meet the control objectives, the desired load voltages and source currents must contain only positive sequence, fundamental frequency components and

$$P_L = |V_L^* I_S^*| \cos \emptyset_1 = |V_S^{1P} I_S^*| \cos \emptyset_S \text{-----------------Eq(3)}$$

where V ¤ L and I¤S are the reference quantities for the load bus voltage and the source current respectively. Ál is the power factor angle at the load bus while Ás is the power factor angle at the source bus (input port of UPQC). Note that V ¤ L(t) and I¤S (t) are sinusoidal and balanced. If the reference current (I¤C) of the shunt converter and the reference voltage (V ¤ C) of the series converter are chosen as

$$I_C^* = I_L^*, V_C^* = -V_S^r + V_c^{1P} \text{-----------------Eq(4)}$$

with the

c
o
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0

we have,

$I_S^* = I_L^{1P}, \; = V_S^{1P} + V_c^{1P}$

Note that the constraint implies that V 1p C is the reactive voltage in quadrature with the desired source current, I¤S . It is easy to derive that

$$\langle V_C^*, I_S^* \rangle = 0 = \langle I_C^*, V_L^* \rangle \text{-------------Eq(5)}$$

The above equation shows that for the operating conditions assumed, a UPQC can be viewed as a inaction of a DVR and a STATCOM with no active power °ow through the DC link. However, if the magnitude of V ¤ L is to be controlled, it may not be feasible to achieve this by injecting only reactive voltage. The situation gets complicated if V 1p S is not constant, but changes due to system disturbances or fault. To ensure the regulation of the load bus voltage it

may be necessary to inject variable active voltage (in phase with the source current). If we express $V_C = V_C^* + \Delta V_C, I_C = I_C^* + \Delta I_C$

$$I_S = I_S^* - \Delta I_C, V_L = V_S^{1p} + V_C^{1p} + \Delta V_C$$

$$\langle I_S, \Delta V_C \rangle + \langle V_L, \Delta I_C \rangle = 0$$

In deriving the above, we assume that

$$\langle I_S, V_C^* \rangle = 0 = \langle V_L, I_C^* \rangle$$

This implies that both ¢VC and ¢IC are perturbations involving positive sequence, fundamental frequency quantities (say, resulting from symmetric voltage sags). the power balance on the DC side of the shunt and series converter. The perturbation in VC is initiated to ensure that

$$|V_C^* + \Delta V_C + V_S| = |V_L| = \text{constant}.$$

Thus, the objective of the voltage regulation at the load bus may require exchange of power between the shunt and series converters.

Fig. (a) shows the switch positions (0 for open and 1 for close) during the simulation period from 0 to 2 s where both the interconnected and islanded modes are observed. The performance of the proposed UPQCμG−IR for voltage sag compensation is shown in Fig. 8(b) and harmonic current compensation is shown in Fig. 8(c) based on Table I. Performance during the reverse current flow to the grid due to the high penetration of DG is also shown by the red circle in Fig. 8(c). In general, waveforms are shown for phase A only.

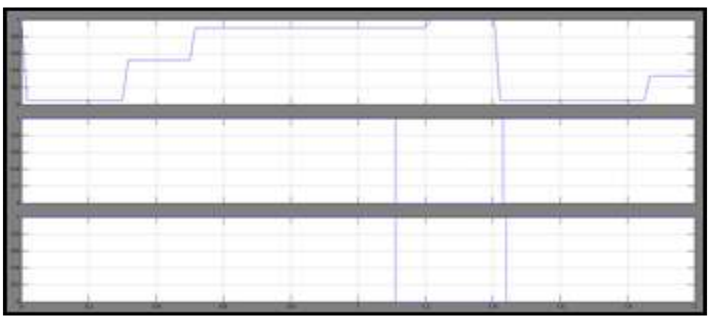
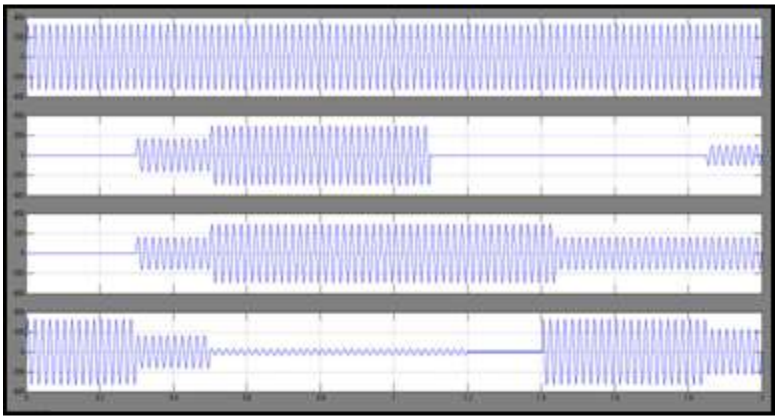
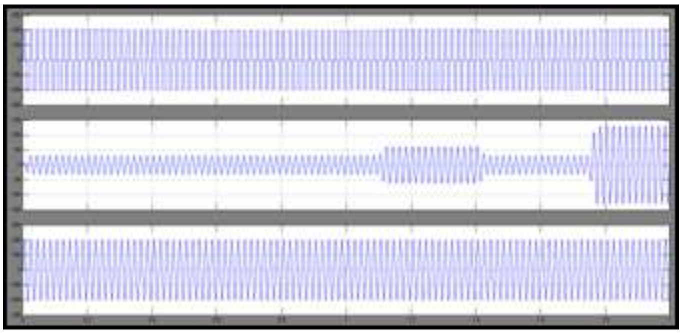


Fig (a) switching position during the operation



Fig(b)voltage waveforms of different conditions and positions in the networks



Fig(c) current waveforms of different conditions and positions in the networks

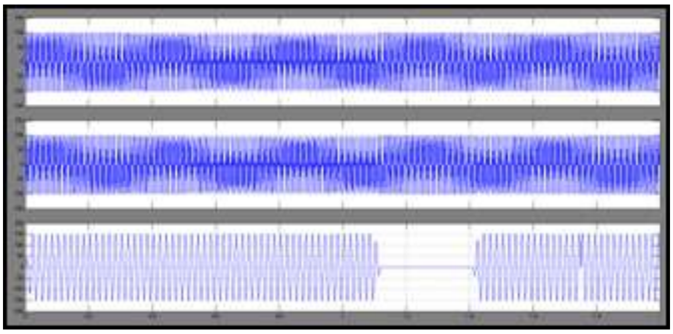


Fig. 10. Performance of APFse in forward-reverse flow condition with compensating voltage sag (80%). (a) Dynamic change of *is*

V. CONCLUSION

This paper describes a powerful control and integration technique of the proposed UPQCμG−IR in the grid connected μG condition. The real-time performance with off-line simulation has been obtained using MATLAB and RT-LAB in real-time simulator by OPAL-RT. The results show that the

UPQCμG−IR can compensate the voltage and current disturbance at the PCC during the interconnected mode. Performance is also observed in bidirectional power flow condition. In islanded mode, the DG converters only supply the active power. Therefore, the DG converters do not need to be disconnected or change their control strategy to keep the μG operating in any time with any condition. Islanding detection and seamless reconnection technique by the UPQCμG−IR and the dynamic change with bidirectional power flow are validated in real-time for a DG integrated μG System without compromising on power quality.

REFERENCES

[1] S. K. Khadem, M. Basu, and M. F. Conlon, "UPQC for power quality improvement in DG integrated smart grid network—A review," *Int. J. Emerg. Electr. Power Syst.*, vol. 13, no. 1, p. 3, 2012.

[2] A. Kahrobaeian and Y.-R. Mohamed, "Interactive distributed generation interface for flexible micro-grid operation in smart distribution systems," *IEEE Trans. Sustainable Energy*, vol. 3, no. 2, pp. 295–305, Apr. 2012.

[3] X. Yu, A. M. Khambadkone, H. Wang, and S. Terence, "Control of parallel-connected power converters for low-voltage microgrid—Part I: A hybrid control architecture," *IEEE Trans. Power Electron.*, vol. 25, no. 12, pp. 2962–2970, Dec. 2010.

[4] S. K. Khadem, M. Basu, and M. F. Conlon, "A new placement and integration method of UPQC to improve the power quality in DG network," in *Proc. 48th UPEC*, vol. 1. Sep. 2013, pp. 1–6.

[5] J. M. Guerrero, J. C. Vasquez, J. Matas, L. G. de Vicuña, and M. Castilla, "Hierarchical control of droop-controlled AC and DC microgrids—A general approach toward standardization," *IEEE Trans. Ind. Electron.*, vol. 58, no. 1, pp. 158–172, Jan. 2011.

[6] B. Han, B. Bae, H. Kim, and S. Baek, "Combined operation of unified power-quality conditioner with distributed generation," *IEEE Trans. Power Del.*, vol. 21, no. 1, pp. 330–338, Jan. 2006