New Control Strategy for Conventional VSI in Islanded Microgrid to Enhance Voltage Quality under Nonlinear Loads

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***Abstract*— This paper proposed a new control strategy for voltage source inverter (VSI) of effective fifth and seventh harmonic reduction in the point of common coupling (PCC) in islanded microgrid under nonlinear load without any additional hardware devices. The non-linear load regularly causes such harmonic distortion, which harmfully affect the performance of other loads or other distributed generation (DG) sources connect to the PCC. In order to improve the quality of delivered output voltage, these harmonic must be rejected. The proposed control strategy is developed based on the current controller formed by resonant controller parallel with a proportional integral controller, which perform on the fundamental reference frame. The reference current is estimated based on the voltage harmonic and the injecting power. The simulation and experimental results are shown to verify the effectiveness of proposed control method.**

***Keywords*— islanded microgrid, harmonic compensation, resonance controller**

I. INTRODUCTION

THE Distributed Generation (DG), relying on renewable energy resources is interest in order to reduce carbon emission and minimize the non-renewable resource to meet the demand. Microgrid concept using coordinated control among parallel DG interface converters has been well accepted [1].

There might be a large number of non-linear loads in the three-phase microgrid, such as single-phase loads, rectifier loads and so on. Thus, the power quality of the islanded microgrid can be deteriorated under non-linear loads since it lacks the voltage and frequency support from the utility [2]. Harmonic-distorted voltage can cause severe problems on equipment such as vibration, over-voltage and so on.

Active power filters (APFs) are commonly utilized to ensure power quality in the utility [3]. Series APFs are usually utilized to compensate the voltage unbalance and harmonics by injecting harmonic voltage to the distribution line through coupling transformers. The usage of APF increases the cost of the system, also increase the complexity in coordinating the operation of units in the system.

To mitigate the above-mentioned complications, this paper proposes a harmonic reduction for voltage source inverter microgrid application. This proposed control scheme is to be used with each individual DG, it consists of two main function: sharing the loads with others DG follows the command of control center; and reducing the harmonic components which generated when microgrid operate under nonlinear loads to improve the voltage quality of whole system.

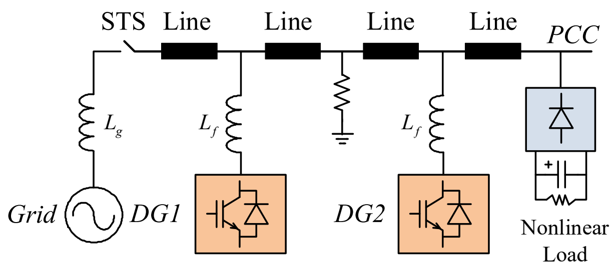

Fig. 1. Typical islanded microgrid configuration.

This paper is organized as follows: The proposed control strategy for voltage harmonics compensation is discussed in detail in Section 2. Simulation and experimental results is carried out in Section 3. At last, the paper is concluded in Section 4.

II. PROPOSED CONTROL STRATEGY

A. Problem in microgrid under non-linear load

Fig. 1 shows a typical ac microgrid in islanded mode when static switch (STS) is open. All DG sources and non-linear loads are connected to the point of common coupling (PCC). As mention earlier, under such nonlinear load, the voltage of PCC is distorted and the harmonic components are multiples of the fundamental frequency of the PCC voltage [4]. The main reason of these harmonics is the non-linear current drawn by the non-linear load. This current leads to a nonlinear voltage drop on the internal impedance of the output filter of the master source. Thus the voltage of the PCC is distorted.

B. Proposed method for PCC Voltage Harmonic Reduction

The control scheme is responsible for producing an induced voltage to compensate the nonlinear voltage drop on the output impedance of the DG1 source. In order to do this, the (6*n*)th harmonic sequence components of PCC voltage in fundamental frame should be share with compensating converter. The block diagram of proposed control scheme is shown in Fig. 2. This control scheme consists of one resonance controller and one proportional-integral-resonance controller (PI-R). First resonance controller is implemented in the synchronous reference (*dq*) frame rotating at fundamental frequency to generate the (6*n*)th (n=1,2…) harmonic injecting current references. The second controller PI-R is also implemented in *dq* frame to control the output current of DG1

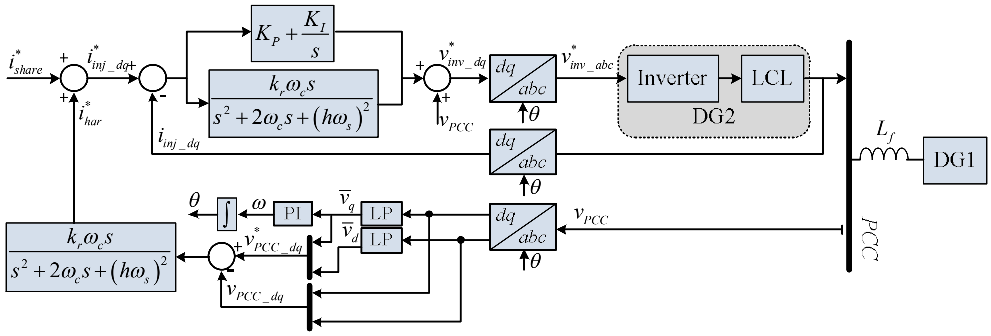

Fig. 2. Proposed control scheme for the VSI in DG

to follow the reference current which is combination of sharing current and harmonic currents.

III. Simulation and Experimental Results

In order to verify the effectiveness of proposed control scheme, the simulation and experimental results are carried out with a ac microgrid consist of two DG sources as Fig. 1. One DG (DG1) source is maintain the PCC voltage and frequency, the remaining DG (DG2) perform with proposed control scheme to share the power with DG1 and also maintain the voltage quality of PCC. These are parameters of the ac microgrid: the voltage of PCC is 60Vrms, 50Hz; total load power is 1.4kW and being shared with DG2. The simulation and experimental results in Fig. 3 and Fig. 4 shown that the proposed control scheme is effective to compensate the harmonic components on PCC voltage, the total harmonic distortion (THD) of simulation results of PCC voltage is around 3% (<5% satisfy IEC standard) .

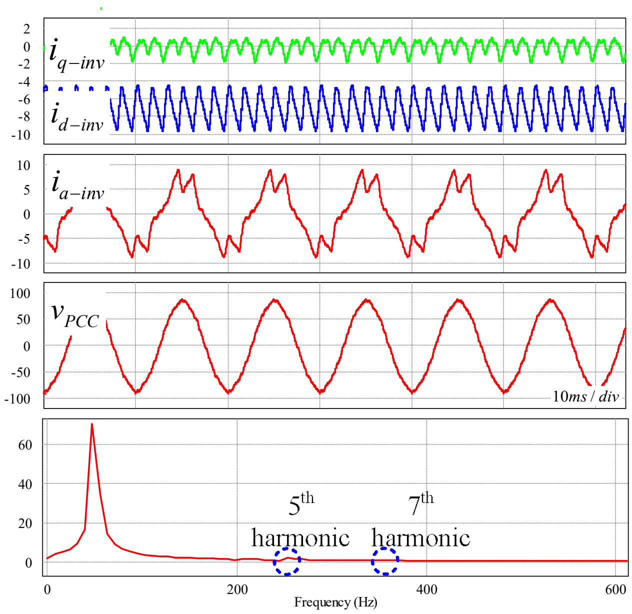

Fig. 3. Simulation Results

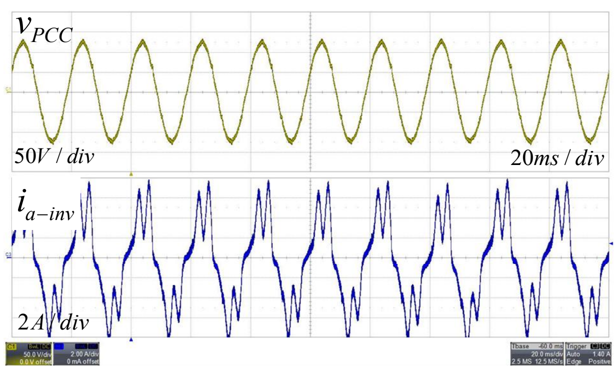

Fig. 4. Experiment results.

IV. Conclusions

A compensation control scheme for the PCC voltage in standalone ac microgrid was proposed in this paper. With the proposed control scheme, the voltage harmonic components on PCC are effectively reduced without any additional hardware devices and power sharing control in the system keeps work properly. The simulation results shows the effectiveness of the proposed topology, and it can be applied easily to control VSI in islanded microgrid.

Acknowledgment

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