Enhanced Reactive Power Sharing and Voltage Restoration in Islanded Microgrid

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***Abstract*— Parallel distributed generators (DGs) in the islanded micro-grid are normally controlled with the aid of the droop control scheme. However, the traditional droop control methods which use the P-ω and Q-E curve to share power between DGs are still concerned to improve the accurate of reactive power sharing and variation of frequency and voltage at the point of common coupling (PCC). This paper proposes a control scheme to solve the limitation of microgrid in islanded operation such as reactive power sharing accuracy and PCC voltage and frequency restoring. In order to achieve the control objective, a secondary control is implemented with both central controller and local controller by using the low bandwidth communications. The effectiveness of the proposed control scheme is analyzed through the simulation.**

Keywords— islanded microgrid, reactive power control, secondary control.

I. INTRODUCTION

In the near future, the use of distributed generation (DG) units including renewable energy resources is expected to be increased in power system and the use of low efficient traditional power plants are anticipated to be decreased. Microgrids are becoming an important part to integrate DG and distributed energy storage system. Comparing to single DG systems, the microgrids provides enhanced performance through the coordinated control among the DG interfacing converters [1].

An indispensable function of microgrid is to achieve desired power management among DG units in islanding operation. Fig. 1 shows a typical configuration of microgrid when the static switch (STS) is open. In the islanded mode, the inverter controllers are responsible for the microgrid stability and power quality. For grid-forming, the voltage source inverter (VSI) is required to regulate the bus voltage under the isolated condition, and the droop control method has been used to generate the voltage reference for VSI.

When using droop control, since the frequency of the microgrid is not affected by the feeder impedance mismatches, the real power sharing capabilities can achieved successfully. However, the reactive power output of each inverter depends on the voltage amplitudes due to the mismatched drop voltage caused by unequal impedance [2]. To avoid the active and reactive power coupling and increase power sharing accuracy, the proper value of virtual impedance is chosen by the control algorithm in this paper. And also, in order to remove the inevitable output voltage drop due to droop characteristic, an

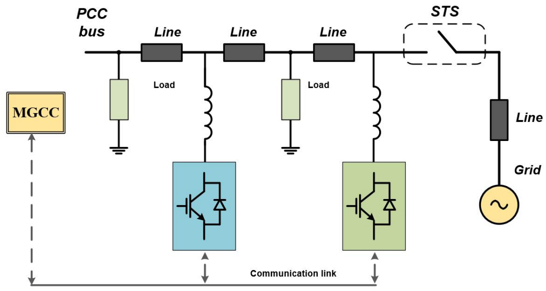

Fig. 1. Typical islanded microgrid configuration

outer loop control is proposed by restoring voltage amplitude and frequency.

II. PROPOSED CONTROL STRATEGY

A. Accurate reactive power sharing

In DG transmission system, the line impedance is mainly inductive X>>R because of the leakage induction from transformer and output filter inductor, so the affect of R can be neglected [3].

An accurate approximation of the line voltage drop can be considered as follows:

$$\Delta V = V_A - V_B \cong \left(XQ_A \right) / V_A \tag{1}$$

To compensate the mismatched voltage drop, the virtual impedance is used, and its proper value is selected by the external loop control through PI controller:

$$L_{Vir} = K_{p\_vir}\left(Q_{average} - Q_i\right) + K_{i\_vir}\int\left(Q_{average} - Q_i\right)dt \tag{2}$$

where $Q_{average}$ is average of reactive power calculate from the total number of DGs, n:

$$Q_{average} = \left(\sum_{i=1}^{n} Q_i\right) / n \tag{3}$$

B. Proposed method for Voltage amplitude and frequency restoration

The Micro-grid central control (MGCC) measures the bus voltage and frequency via the low bandwidth communication, and regulates the bus voltage and frequency by two separate PI controllers. The additional ΔE_{res} and Δf_{res} are added into the droop reference value to shift the output voltage into its nominal value:

$$\Delta E_{res} = K_{p\_E}\left(E_{MG}^{*} - E_{MG}\right) + K_{i\_E}\int\left(E_{MG}^{*} - E_{MG}\right)dt \tag{4}$$

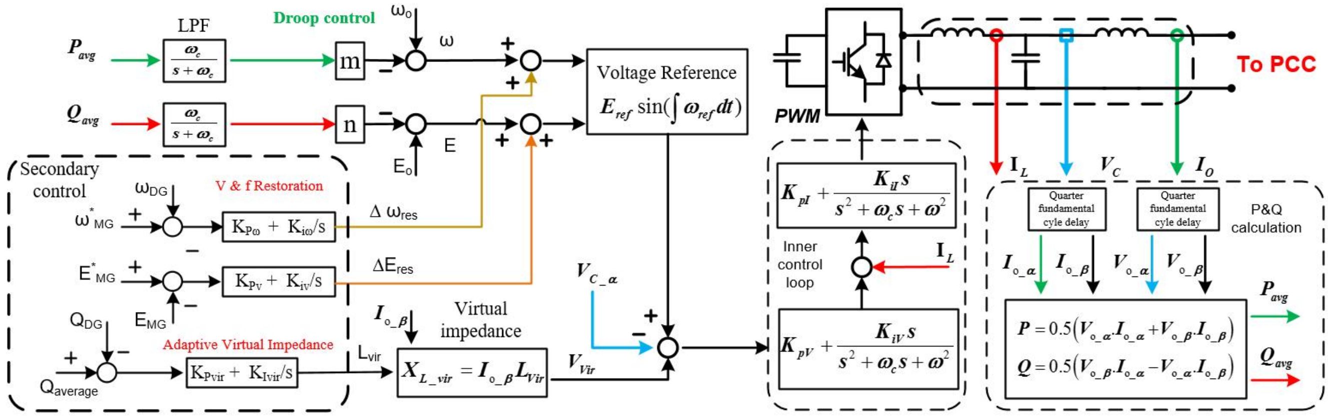

Fig. 2. Proposed control scheme for the VSI in DG

$$\Delta\omega_{res} = K_{p\_fre}\left(\omega^*_{MG} - \omega_{MG}\right) + K_{i\_fre}\int\left(\omega^*_{MG} - \omega_{MG}\right)dt \quad (5)$$

The proposed control diagram is shown in Fig. 2.

III. Simulation Results and Analysis

In order to verify the effectiveness of the proposed control, the simulation is executed with the microgrid including 2 DGs. In the simulation, the voltage of PCC is 110V, 50Hz; total load power is 1kW and 465var shared with DG1 and DG2.

Fig. 3 shows the reactive power sharing performance of the proposed control scheme. In Fig. 4, PCC Voltage and frequency are recovered to their nominal values, 110V and 50Hz, respectively, after the secondary control of voltage and frequency restoration are activated at 4s and 4.1s, respectively. From the simulation, the proposed reactive power sharing method shows a good response with small error. In addition, PCC voltage and frequency can be maintained to satisfy the quality of the voltage system.

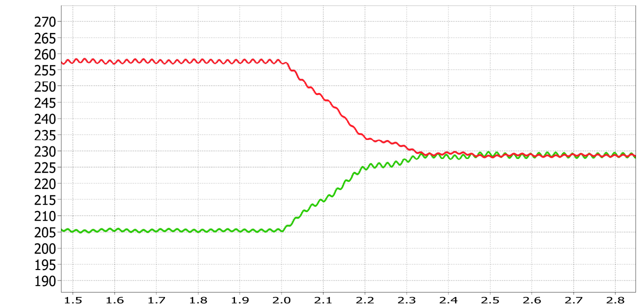

Fig. 3. Reactive power sharing between DG 1 (red line) and DG 2 (green line)

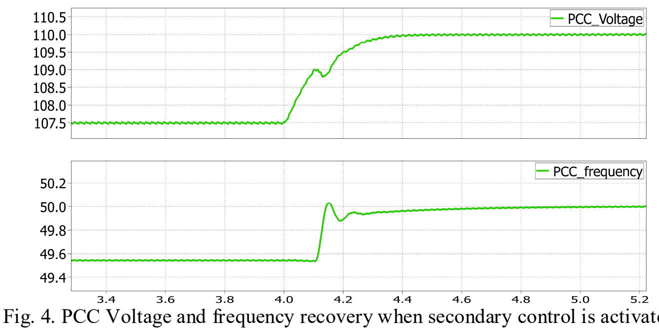

Fig. 4. PCC Voltage and frequency recovery when secondary control is activated

IV. Conclusions

This paper presented a control scheme for parallel inverters in micro grid to achieve reactive power sharing together with PCC voltage and frequency recovery. With the proposed control scheme, the virtual impedance is adaptively tuned to share the reactive power. Furthermore, the MGCC calculates the restoring value base on the measured PCC voltage and frequency, and the low bandwidth communication is applied. The proposed restoring loop controller provides a good steady-state performance with fast response with the secondary control. A series of simulation results shows the effectiveness of the proposed control scheme.

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