# A Virtual Impedance Optimization Method for Reactive Power Sharing in Networked Microgrid

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***Abstract*—Unlike the typical microgrid with a common ac bus, networked microgrid always suffers more serious reactive power sharing issues due to its complex inner structure. In such case, the system reactive power sharing error cannot be easily evaluated and eliminated. So, this paper proposes a wireless control strategy that employs optimized virtual impedance controllers and local load measurements for the reactive power sharing in networked microgrid. First, from the modeling of microgrid network, an estimation method for network reactive power sharing error is derived. Through the estimation method-based network feature analyses, corresponding design for virtual impedance controller is presented. Then, by introducing genetic algorithm, virtual impedance controller parameters of each distributed generation unit are optimized, which aims to minimize the microgrid global reactive power sharing error. The parameter optimization process is performed offline in microgrid configuration stage. By using these optimized virtual impedance controllers, the reactive power sharing performance of a networked microgird can be greatly improved. Finally, the accuracy of the estimation method is validated by MATLAB simulation results, and the feasibility of the proposed virtual impedance optimization method is verified through real power experiments.**

***Index Terms*—Estimation method, genetic algorithm (GA), networked microgrid, reactive power sharing, virtual impedance.**

## I. Introduction

With the increased concerns on environment and clean energy, more and more renewable energy sources such as photovoltaic cells, wind turbines, and microturbines are integrated into the power grid in the form of distributed generation (DG) units. These DG units are normally interfaced to the grid through power electronic converters. To effectively manage these DG units, the microgrid concept is proposed, which is considered to pave the way to the future smart grid [1]–[3]. Microgrid usually connects to the power grid through the point of common coupling (PCC); it can operate in either islanded mode or grid-connected mode. Microgrid can not only solve the problem of large scale DG coupling but also play full advantages of DG units, improve power supply reliability and bring more benefits to its users. However, microgrid also faces some challenging problems, such as control stability and power sharing issues.

In an islanded microgrid, loads must be properly shared by multiple DG units. Conventionally, the frequency and voltage magnitude droop control method is adopted, which mimics the behavior of synchronous machines in power systems [4]–[9]. The droop control technique provides a decentralized control capability, which makes the microgrid operation independent of communication links. This wireless control manner enables the "plug and play" interfacing of DG units and also enhances the reliability of system. Although the frequency droop control always achieves accurate real power sharing, the voltage droop control typically results in poor reactive power sharing due to the mismatch in feeder impedances, and also to the different offsets of local loads. Moreover, when the microgrid structure is networked, the reactive power sharing issue will be further aggravated due to the irregular distribution of DG units.

To improve the reactive power sharing performance of droop control, many solutions have been developed [10]–[18]. In [10], reactive power sharing errors are reduced through the injection of a small ac voltage signal in the system. However, this approach may reduce the quality of DG output voltages and line currents. As an important tool for droop control method, the well-known virtual impedance method can enhance the system stability and reactive power sharing accuracy at the same time. In [11] and [12], predominant virtual inductors are placed at DG unit outputs, which mainly aimed to prevent the power control instability. In [13]–[16], a comprehensive treatment about virtual impedance concept is presented. The focus has been on the mismatched output impedances of closed-loop controlled DG units, while the mismatch in feeder impedances has not been considered. Thus, reactive power sharing issues cannot be solved completely. In [17], reactive power sharing errors are reduced through the modification of droop control slopes. With the preset virtual inductor and estimated feeder impedance value, the slope of $Q$–$V$ droop control is modified to compensate the mismatch in feeder voltage drops. In [18], communication is introduced to facilitate the estimation of feeder impedance value, making the system reactive power sharing more accurate. Aforementioned reactive power sharing strategies have considered the impacts of DG output impedances, feeders, and local loads. However, in a networked (multi-bus) microgrid, besides aforementioned mismatched factors, the networked structure is

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