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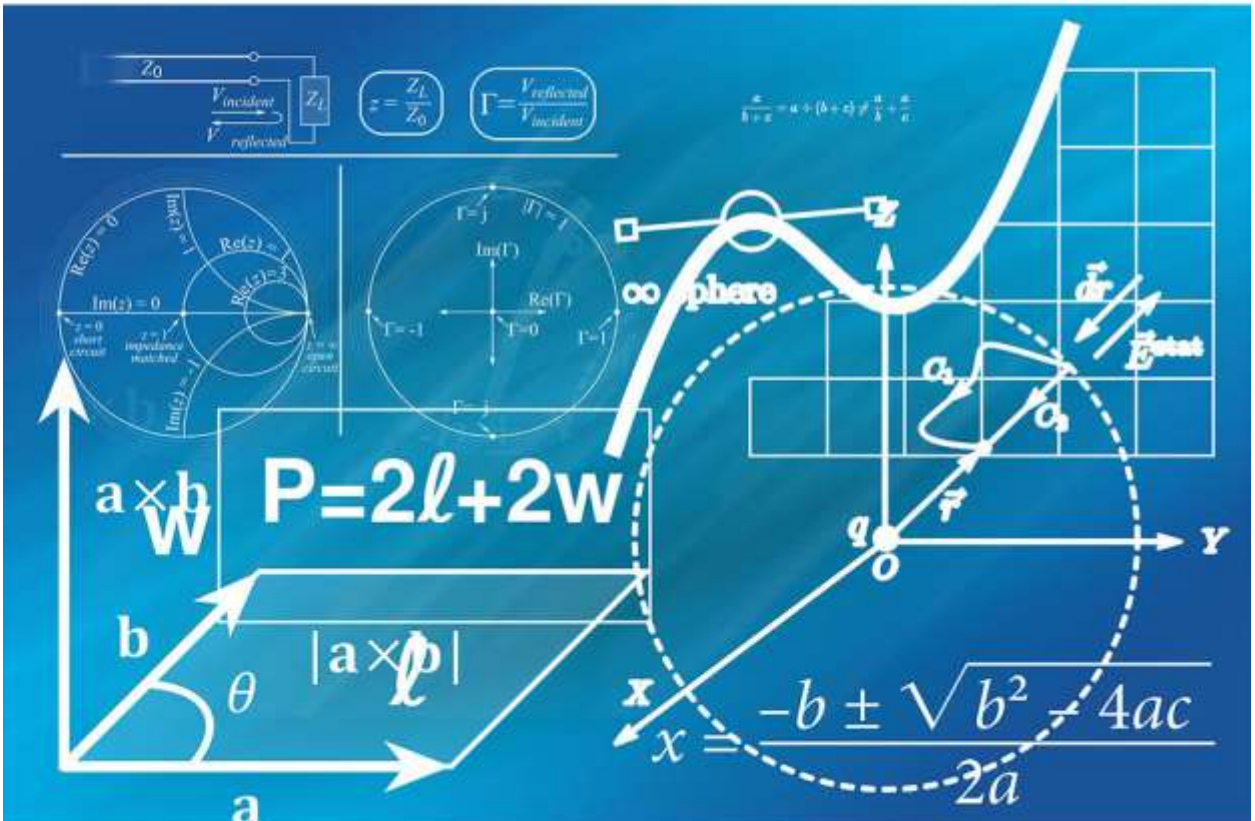

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Survey on Power Intersegment Control Strategy of Multilevel Invertor for Grid System

Rakesh Kumar
M. Tech scholar
Corporate Institute of Science and Technology
rakkeer1994@gmail.com

Mr. Anurag Khare
Assistant professor
Corporate Institute of Science and Technology
anuragkhare143@gmail.com

ABSTRACT

Among the issues of accurate power distribution, stability improvement, and harmonic suppression in micro-grid, each has been well studied as an individual, and most of the strategies about these issues aim at one inverter-based micro-grid, hence there is a need to establish a model to achieve these functions as a whole, aiming at a multi-inverter-based micro-grid. This paper proposes a comprehensive strategy which achieves this goal successfully; since the output voltage and frequency of micro-grid all consist of fundamental and harmonic components, the strategy contains two parts accordingly. On one hand, a fundamental control strategy is proposed upon the conventional droop control. Finally, small signal analysis can be used to analyze the stability of the multi-converter parallel system after introducing the whole control strategy.

Keywords: micro-grid; droop control; virtual impedance; harmonic suppression; power quality

I.Introduction

In recent years, distributed generations, e.g., wind and solar power, have been developing rapidly. Comparing with traditional power generation forms, distributed generations are environment-friendly technologies, and they often form micro-grids via inverters, which is an important complementary of bulk power network. However, since there are so many distributed generations in the micro-grid system, power electronic inverters are also widely used. In addition, various kinds of nonlinear loads such as electric vehicles are increasingly integrated into the micro-grid, thus a power quality problem inside micro-grid occurs and increases problems of heating, incremental losses, voltage and current distortion, which threaten our daily life. It is not only the micro grid itself that can be broken down by such problems, but the voltage and frequency of the distributed power system can also be influenced through the point of common coupling (PCC) [1,2,3]. Meanwhile, power management strategies play an increasingly important role in power quality regulation for micro-grids.

As distributed generations are connected to the micro-grid via inverter, hence the control strategy of inverters influence system stability and power quality. Among all the inverter control strategies, droop control is considered as the best strategy at present, which can distribute the output power of inverters properly under the island mode of the micro-grid, even if there is no common communication line among distributed generations (DGs); meanwhile, the voltage and frequency can be controlled within related national standards by this strategy [7,8,9]. However, there are some shortcomings in the traditional droop control strategy. Firstly, system reactive power cannot be distributed accurately while the equivalent impedance of micro sources is different [10]. Secondly, system voltage and frequency will not maintain their stability under abrupt load variation [11, 12]. In addition, the magnitude of harmonic power varies with the amount of non-linear loads integrated into the micro-grid. The existence of harmonic power will have an effect on system devices, including transformers, capacitors, and electric rotating machines. It is also shown that harmonic power will influence the voltage amplitude and waveform of PCC [13], which may cause resonance and eventually lead to the loss of system stability.

Traditional methods for limiting waveforms distortion are to make direct compensation by installing passive or centralized active power filters, but the high cost of these kinds of devices should not be ignored, and these methods can only improve harmonic components, while, as to fundamental component power quality and accurate reactive power distribution, they neither make tense research nor give an integral solution. proposed a compensation method based on a unified power quality conditioner (UPQC) to improve the power quality index of PCC, but though this device is widely used in large capacity and high voltage power grids, it is difficult to generalize the use of this device in low voltage distributed grids and micro-grids. Many experts considered designing an inverter control strategy to improve accurate reactive power distribution and govern harmonic components. proposed a method to govern harmonic components in the micro-grid that combines the technology of active filter and inverter controller, so the utilization of inverter is obviously improved and the cost of active filter is effectively decreased; however, the design of that controller is too complex to popularize. The general method to distribute reactive power accurately is to add virtual impedances into inverters. By measuring the output voltage and current of inverters and adjusting their output impedances, i.e., introducing virtual impedances to the multi-inverter system, the reactive power of system can be distributed accurately, although this method needs to know the parameters of lines in advance and is short of consideration about load variation. concluded that harmonic droop control can be used for distributing harmonic power among inverters and decreasing voltage waveform distortion of PCC, whereas the calculation of non-linear loads is too complex and this method does not make an obvious function on distributing active power. Proposed a control strategy to suppress harmonic and negative sequence current in island mode. The strategy mentioned is composed of two controllers: one is a multi-proportional resonance controller which is used to regulate load voltage, and the other is a harmonic impedance controller which is used to distribute harmonic current among micro sources.

II. Literature Review

Henan Dong et al. [1] Among the issues of accurate power distribution, stability improvement, and harmonic suppression in micro-grid, each has been well studied as an individual, and most of the strategies about these issues aim at one inverter-based micro-grid, hence there is a need to establish a model to achieve these functions as a whole, aiming at a multi-inverter-based micro-grid. This paper proposes a comprehensive strategy which achieves this goal successfully; since the output voltage and frequency of micro-grid all consist of fundamental and harmonic components, the strategy contains two parts accordingly. On one hand, a fundamental control strategy is proposed upon the conventional droop control. The virtual impedance is introduced to solve the problem of accurate allocation of reactive power between inverters. Meanwhile, a secondary power balance controller is added to improve the stability of voltage and frequency while considering the aggravating problem of stability because of introducing virtual impedance. On the other hand, the fractional frequency harmonic control strategy is proposed. It can solve the influence of nonlinear loads, micro-grid inverters, and the distribution network on output voltage of inverters, which is focused on eliminating specific harmonics caused by the nonlinear loads, micro-grid converters, and the distribution network so that the power quality of micro-grid can be improved effectively. Finally, small signal analysis is used to analyze the stability of the multi-converter parallel system after introducing the whole control strategy.

Shun Yuan et al. [2] this paper has a great performance on distributing reactive power, regulating and eliminating harmonic components, eliminating negative sequence components and stabilizing output voltage of inverters and frequency, and improving the power quality of multi-inverter-based micro grid. the influence of nonlinear and unbalance mixed loads on output voltage of micro source inverters in micro grid, this paper proposes a comprehensive strategy which can be used to accurate power distribution, harmonic suppression, negative sequence voltage component suppression and stability improvement. On one hand, a fundamental control strategy is proposed upon the conventional droop control, the problem of accurate reactive power distribution is solved by introducing virtual impedance to inverters, while considering the aggravating problem of stability because of introducing virtual impedance, a secondary power balance controller is added to improve the stability of voltage and frequency. On the other hand, the fractional frequency harmonic control strategy and negative sequence voltage control strategy are proposed to solve the influence of mixed loads, which is focus on eliminating specific harmonics caused by the nonlinear loads and the negative sequence component of the voltage. The power quality of micro grid can be improved effectively.

III. Comprehensive Strategy for Accurate Reactive Power Distribution, Stability Improvement, and Harmonic Suppression of a Multi-Inverter-Based Micro-Grid

It is difficult to accurately distribute reactive power and effectively improve the stability of voltage and frequency under abrupt load variation depending on conventional droop controllers, let alone suppress harmonic components in a micro-grid which are caused by many reasons. Therefore, a comprehensive strategy for accurately distributing reactive power, improving stability, and suppressing harmonics of a multi-inverter-based micro-grid is proposed in this paper. Upon the conventional droop control, an adaptive virtual impedance control loop is introduced to achieve the accurate distribution of reactive power of inverters in fundamental frequency. Considering this process may add the problem of voltage stability, so a secondary power balance controller is added to improve the stability of voltage and frequency, and the fundamental problems are settled completely so far. Next, the control strategy this paper proposed is further refined by introducing a fractional frequency harmonic suppression strategy, which can solve the harmonic problem perfectly, therefore, the power quality of the micro-grid is improved eventually.

The main circuit is mainly composed of the following parts: inverter, LC filter, line impedance, linear load, nonlinear load, and so on. The inverter is controlled by a control strategy to adjust the output voltage and frequency. The comprehensive control strategy is composed of the improved fundamental control strategy and fractional frequency harmonic control strategy.

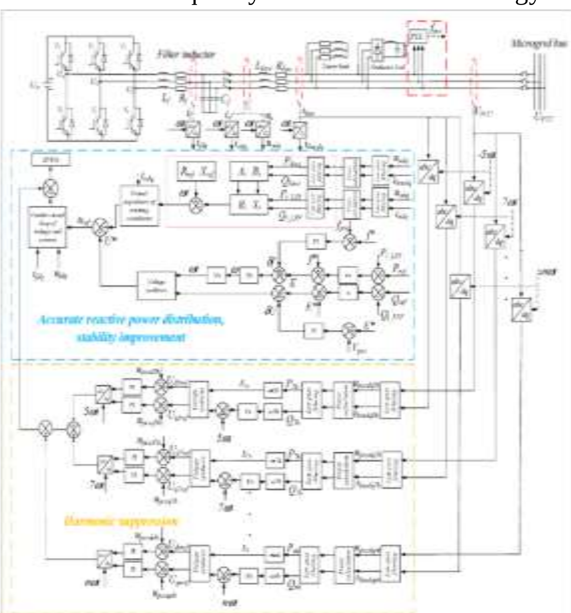

Figure 1 Block diagram of comprehensive control strategy

IV. Distributed Line Impedance

The case for distributed line impedance is different. We have considered three ways to change the line impedances, when scaling from 24.9kV to 12kV system: (i) halving the R/L matrix, (ii) halving the length of lines, and (iii) halving the length of line and quadrupling the capacitance matrix. Methods (i) and (ii) yield similar results but the voltage drop is larger than the original case. Method (iii) cuts the line power flow in half and at the same time keeps the nodal voltages in per unit the same. Therefore, we have used method (iii) to scale the distributed line impedances.

V.Microgrid Components

A backbone of a typical micro grid is as similar to a traditional distribution system, a general micro grid includes all the basic components that distribution system has such as distribution feeder circuits, protective equipmentsand switches, primary circuits, distribution tr ansformers and regulators, different types of customers (loads). Other than that, since micro grid is able to be islanded

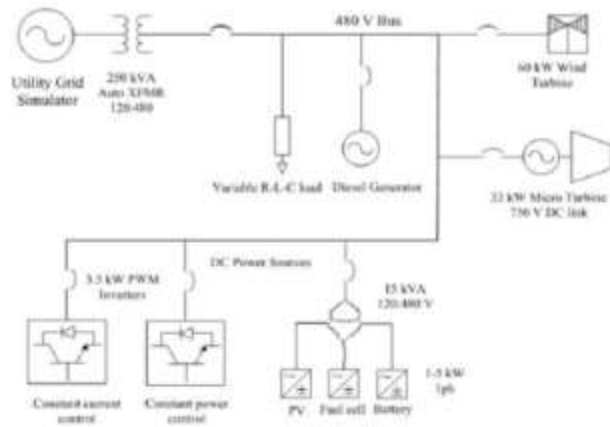

Figure 2 A typical micro grid backbone diagram

From the bulk grid, it is required to install other components and devices so that a high performance power management for steady states and transitions operations can be realized. These components are: distributed generations, advanced metering and monitoring, supervisory control units, and interconnectivity devices. Distributed generations which play an important role of supporting local loads within the micro grid are necessary to be added to the system. There are typically three types of powergenerations installed in the microgrid. First are t he renewable energy generations, as they are the green energy and one benefit of the micro grid is that the micro grid are necessary to be added to the system. There are typically three types of power generations installed in the microgrid. First are the renew able energy generations, as they are the green energy and one benefit of the micro grid is that the micro grid provides the most promising means of integrating a large amount of renewable energies in the system. In this paper two 750kW wind turbines and one 250kW PV are added to the system. The sizing issue and power profiles are describe in the following section. Second are the energy storage systems, as they play a role of smoothing the intermittency of renewable energy, and a key part of managing power flow and voltage stability in the micro grid.

VI. Conclusion

This paper proposes a comprehensive strategy for accurate reactive power distribution, stability improvement, and harmonic suppression of a multi-inverter-based micro-grid. With the combination of virtual impedance droop control and secondary power balance control, the active and reactive can be distributed accurately, meanwhile the stability of voltage and frequency are obviously improved. Next, a harmonic suppression control strategy is introduced to suppress harmonic components in the micro-grid. Furthermore, small signal analysis is used to analyze the stability of the proposed multi-converter parallel system after introducing the comprehensive theory.

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