

# Discussion on the Factors Affecting the Stability of Microgrid Based on Distributed Power Supply

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## ABSTRACT

This paper summarizes the advantages of application of micro grid, analyzes the structure of microgrid, and discusses the factors, which are important to the stable operation of micro grid. The factors include the technology of power matching, harmonic suppression and the stability of electronic cascaded systems etc.

**Keywords:** Microgrid; Distributed Generation; Stability Analysis; Energy Storage

## 1. Introduction

With the progress of human society, electric power has been the symbol of modern civilization. Power supply reliability and power quality have become more and more important. Facing pressures from traditional resource depletion and environmental pollution, power generation methods based on fossil fuel and the centralized power supply mode have been difficult to meet the requirements of economic and social development [1]. With the development of power electronic technology and modern control theory, microgrid, which integrates distributed generations, energy storage device, loads and control modules, is considered progressive to meet the growing power demand [2]. Micro grid provides a method for distributed generation access to utility grid, especially for photovoltaic cells, wind power generation, fuel cell and super capacitor etc. Micro grid promotes the development and utilization of renewable energy. There is great significance to solve the problem of electricity in remote areas of China.

The CERTS has set up a microgrid test platform as shown in **Figure 1**. The definition of microgrid given by CERTS (the Consortium for Electric Reliability Technology Solutions) is: Microgrid is composed of loads and micro power generations, it can simultaneously provides electricity and heat; power electronic devices are responsible for the conversion of energy and the necessary control; microgrid is regarded as a controlled unit for utility grid, and meet the requirements of power supply reliability and power quality at the same time. The techniques comprising the CERTS Microgrid concept are: 1) A method for effecting automatic and seamless transitions between grid-connected and islanded modes of operation;

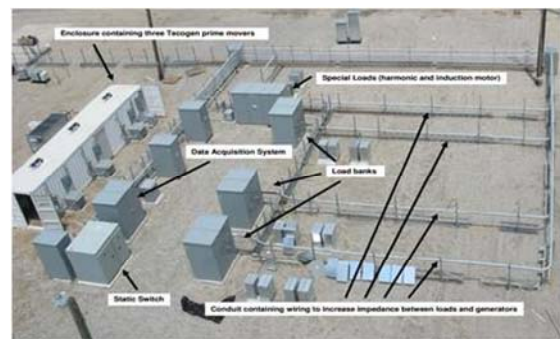
2) An approach to electrical protection within the microgrid that does not depend on high fault currents; and 3) a method for microgrid control that achieves voltage and frequency stability under islanded conditions without requiring high-speed communications.

Researches on microgrid are mainly concentrated on the stable operation. The main factors that hinder the development of the microgrid include nonlinear load statistics theory, power matching technology, harmonic hazard, stability of electronic cascaded systems etc [3]. Operation control and energy management technologies based on correct theoretical basis are important to achieve optimal and stable operation of microgrid.

## 2. Structure and Characteristics of Microgrid

### 2.1. The Structure of Microgrid

Microgrid is mainly composed of micro power supply, energy storage device and electrical / thermal load,



**Figure 1.** Micro power grid test platform in Dolan Technology Center.

through the static switch connecting to low-voltage distribution network. It can realize the smooth and seamless transfer between islanding mode and grid-connected mode. The control, measurement and protection function of operation is based on the power electronic interface. The main structure of microgrid can be DC microgrid, AC microgrid and AC / DC hybrid microgrid and so on.

AC microgrid is the main form of microgrid. Its typical structure is shown in **Figure 2**. In AC microgrids, distributed generations and energy storage devices are connected to the AC bus through power electronic devices. Through the control of the static switch which connects microgrid and utility grid, can realize the mode transfer between grid-connected mode and islanded operation.

The structure of DC microgrid is shown in **Figure 3**. It is obvious that distributed generations, energy storage devices and loads are connected to the DC bus through power electronic converters. DC microgrid connects to the external AC network through the inverter device. DC micro grid can provide power to AC, DC load of different voltage-grades through power electronic conversion devices. The energy storage systems connected to DC bus, compensate the fluctuation of distributed generations and loads.

Compared with AC microgrid, DC microgrid adopts only exist only one-level voltage conversion device be-

tween each DGs, there is more advantages in circulating current restraining.

AC / DC hybrid microgrid contains both AC bus and DC bus. It can supply power to AC loads and DC loads directly. Actually, AC / DC hybrid microgrid can be regarded as AC microgrid, because DC microgrid is a certain power supply which connects to AC bus through a power electronic inverter.

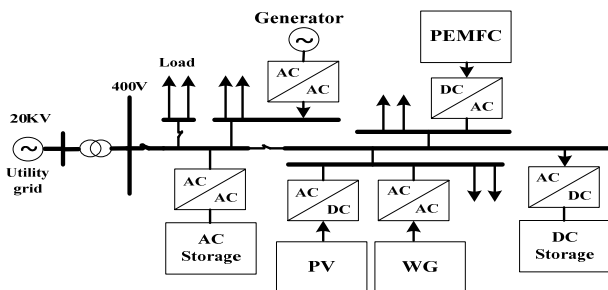
**2.2. The Characteristics of Microgrid**

Microgrid has kind of a dual role. For the power enterprises, microgrid can be regarded as a simple scheduling load, which can make the response to meet the needs of transmission system in seconds. For the users, microgrid can be used as a customizable power, which can satisfy the users' diversified requirements, increase the local power supply reliability and improve the quality of electricity etc. Microgrid technology is the organic combination of the power electronics, distributed generation, renewable energy power generation technology and energy storage technology[4]. Microgrid generally has the following advantages: Microgrid is different from the large power system. It is a small system that is composed of miniature distributed power supply and loads. It can regulate the power supply capacity and the scale of the load with a flexible strategy.

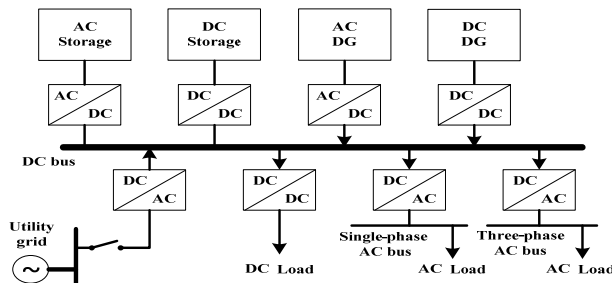
The type of distributed generation is different. It includes traditional power diesel engine, fuel cell, photovoltaic plant, wind power generation and other renewable energy generation. Along with massive applications of the power electronic equipments, the proportion of non-linear loads in microgrid increases. Energy storage equipment, such as super capacitor and battery, is necessary condition for stable operation of the system.

According to the different operating conditions, the microgrid can choose different modes of operation.

With the development of control strategy, the reliability of power supply is improved[5]. There are some defects in the system structure of microgrid. Microgrid adopts a large number of power electronic devices as the interface. As a result, the inertia of distributed generations is small, compared with the conventional generator. Distributed generations do not good in the performance of over load. Because of the small inertia, microgrid needs energy storage equipments to achieve the power balance between supply and load[6]. The two defaults of microgrid have a great influence on the stable operation of the system.



**Figure 2. The structure of AC microgrid.**



**Figure 3. The structure of DC microgrid.**

tween DGs and DC bus, reducing the cost of system construction. As a result, the control methods become simple. It is helpful to stable operation. At the same time, since it is unnecessary to consider the synchronization problem

**3. Analysis of Stability Factor**

After 10 years of development, although the microgrid has made great progress in operation control, energy management and conservation technologies, but small inertia, nonlinear load ratio increasing and harmonic

harm are the problems that hinder the application of microgrid. Factors affecting the stable operation of microgrid include:

a) Microgrid itself is a small capacity power supply system. Its power capacity is limited, and is comparable with the load. While the different sorts of loads have wide and frequent dynamic range, the bus voltage will fluctuate in wide range. In order to keep the stability, the energy storage equipments have to provide a quick response. Power supply and load matching is an essential condition for the operation of power system, especially in microgrid. However, traditional load statistical methods are based on average power theory. They do not apply to nonlinear loads, which introduce harmonics into the microgrid[7]. What's more, the present theory does not consider the effect of harmonics on load and power supply. For an example, while a certain power supply system is rich in harmonics, the actual output of active power of a diesel generator of which the rated power is 120 KW, is only 55 KW. The action principle between the harmonic and Synchronous motor is not clear. In the engineering application, the resolution is to configure larger power motor leading to wasting of resources. Under the condition of large harmonics, power matching has been a problem. At the moment, the study methods are based on the average modules of converters and control system. But the average module cannot describe the time-variant characteristic of converters exactly[8]. According to the analysis requirement of nonlinear electric power system, the instantaneous power theory provides a feasible method to solve the time-variant and nonlinear problems. At home and abroad, the scholars have applied the instantaneous power theory to make a lot of researches on the nonlinear power system.

b) Distributed generation is based on power electronics technology. Its impact on the power quality is mainly caused by the voltage flicker and the introduction of a large number of harmonics. Part of the distributed power is greatly influenced by natural conditions, so that it is difficult to generate stable power[9]. The great changes in output and the interaction between distributed units and medium voltage feedback devices both can cause voltage flicker and impact to the power grid. To enhance the reliability of distributed generation and the application of energy storage equipment are effective ways to solve voltage fluctuation problems such as voltage pulse, voltage flicker and power supply interruption etc. It promotes the energy storage device development in energy density, response time and cost performance.

c)The application of power electronic devices in microgrid, bring the problem of converter cascade stability. as nonlinear switching circuits, its Impedance is time-varying and nonlinear[10]. When the structure of the power electronic devices is complicated, it is difficult to predict the stability with conventional impedance ratio

methods. Besides adjusting the impedance ratio, adding Intermediary filter and designing bus controller are effective methods to improve the cascade stability. At the moment, the domestic study on cascade stability is very limited. At abroad, only a few scholars are doing the relevant theoretical analysis and application research, such as F. C. Lee of VT, M. Ehasani of Texas A&M University. In microgrid, converters cascade stability still needs a lot of research work.

#### 4. Conclusions

Microgrid based on distributed generation is powerful supplement and effectively support of utility grid. Also, it's one of the important trends of power system in the future. Power matching theory, energy storage technology, converter cascade stability and harmonic suppression are the bases of operation control and energy management[11]. With the development of nonlinear power system, microgrid will play an important role in application of new energy.

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