Research on Fault Analysis and location in DC microgrid

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Abstract: Firstly, the paper analyzes the basis of fault location of DC microgrid, and points out the importance of the selection of grounding mode and fault feature analysis for fault location. After that, the existing fault location principles of DC micro grid are classified and studied. The fault location methods of DC micro grid are divided into injection signal method and fault analysis method. It is pointed out that: all kinds of algorithms have advantages and disadvantages; injection signal method is suitable for off-line fault location, fault analysis method is suitable for on-line fault location, and the accuracy of the two location methods is greatly affected by the transition resistance; the existing fault location methods The location algorithm can not locate single pole ground fault and short circuit fault at the same time, and there are many factors restricting its location accuracy. Finally, the key problems of DC micro grid fault location are pointed out, and the future of DC micro grid fault location is prospected.

1. Introduction

Compared with the modular multilevel converter, the existing DC power system based on voltage source converter (VSC) adopts pulse width modulation technology, which has the advantages of simple structure, low cost, easy control and so on. However, when the DC line breaks down, the DC large capacitance will discharge rapidly, coupled with the low impedance of the line itself, the fault current will be within a few milliseconds Reaching the peak value, it is a great threat to the power electronic devices in the system. Therefore, in order to avoid system equipment damage and quickly restore the normal operation of the system, the fault should be removed as soon as possible after the fault occurs and the fault point should be accurately located. It is necessary to locate faults quickly and accurately, which is helpful for the system to repair, restore power supply and reduce the outage time. Therefore, the fast and accurate fault location is of great significance for the DC micro grid to resume normal operation.

2. Fault Location Basis of DC Microgrid

2.1. Basic concepts

1) Concept of DC microgrid

Microgrid is a common concept in AC and DC power systems. It is a small-scale low-voltage or medium-voltage power grid composed of load and distributed power. It can not only be connected to the grid but also run independently from the grid. If the load and distributed power are connected to the public DC bus, DC micro grid will be formed. DC micro grid is not only superior to AC micro grid in terms of operation efficiency and power supply flexibility, but also easier to accept renewable energy than AC micro grid. The DC microgrid is a typical structure, which integrates distributed power sources such as photovoltaic power generation, wind power, fuel cell and battery. It can be connected to the AC power grid through converter, and can supply DC load and AC load.

2) Meaning of fault location

The object of fault location is mainly fault line, which has two meanings: first, rough fault location, after the system fault occurs, determine the approximate location or fault section of the fault; second, accurate fault location, after the fault occurs, accurately determine the location of the

fault point, that is, determine the distance from the measurement end to the fault point, also known as fault location. This paper mainly studies the second fault location

2.2. System grounding mode

Whether it is AC system or DC system, the selection of grounding mode is very important. Different grounding modes will lead to different ground fault characteristics, which will not only affect the selection and setting of protection, but also affect the formulation of fault location strategy

2.3. Fault characteristics

Fault feature analysis is not only the basis of protection scheme selection, but also the basis of fault location algorithm. Only when the fault feature is defined, can a suitable fault location algorithm be formulated. There are two types of simple faults in VSC based bipolar DC system: short circuit between poles and single pole ground fault. When a path is formed between the positive and negative lines, it is a short circuit fault between the poles; when a path is formed between the positive or negative lines and the earth, it is a single pole ground fault. The probability of single pole earth fault is the highest, and the harm of short circuit between poles is the greatest. Two kinds of faults are shown in Figure 1. F1 is single pole ground fault and F2 is inter pole short circuit fault.

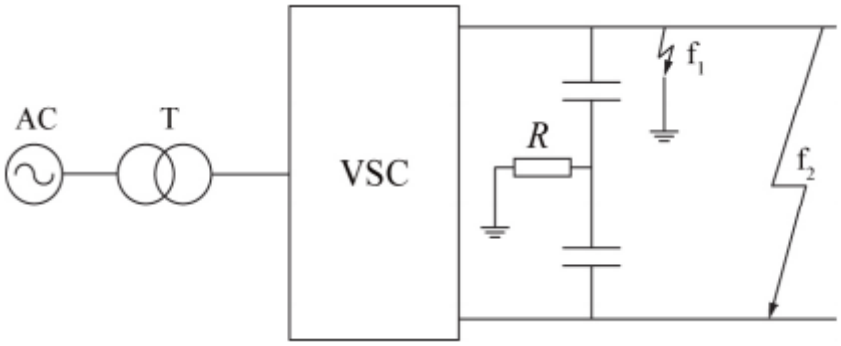

Fig.1. Two simple faults of DC microgrid

For the short circuit fault between poles, in order to avoid the damage of system equipment, it is necessary to avoid the occurrence of diode continuous current stage as much as possible, to avoid the large fault current flowing through the diode, and to cut off the fault circuit before the end of capacitor discharge stage. For single pole ground fault, when the ground resistance is constant, the fault current and the time limit of fault removal are mainly affected by the fault resistance. The smaller the fault resistance is, the faster the fault current rises and the larger the peak value is, the higher the requirements for clearing fault time limit are; the larger the fault resistance is, the slower the fault current rises and the smaller the peak value is, the lower the requirements for clearing fault time limit are.

3. Research status of 2 DC micro grid fault location

Based on the above analysis, domestic and foreign experts have carried out a lot of research on fault location algorithm. Based on the division method of fault location in DC transmission lines, the existing fault location algorithms of DC microgrid are divided into two types: injection signal method and fault analysis method. Traveling wave method, which is widely used in DC transmission lines, can accurately locate faults in a short time, but DC microgrid lines are much shorter than DC transmission lines and need a high sampling rate, so it is generally not used in DC microgrid.

3.1. Fault location by injection signal method

The fault location principle of the injection signal method is shown in Figure 2, where u

represents the location module, IU is the discharge current generated by the location module, l and D are the total line length and fault distance respectively. The basic principle of the injection signal method is: after the fault occurs, the positioning module u injects additional signal IU into the fault line. According to the response of the signal in the fault line (generally the voltage and current at the measuring point), the fault line parameters (inductance or resistance) are calculated, thus the fault distance D is obtained, and finally the fault location is realized. The injection signal method can be divided into offline method and online method according to whether to cut off the fault line before injecting the signal: offline method will inject the signal to the fault line after cutting off the fault line; online method will inject the signal directly to the fault line without cutting off the fault line.

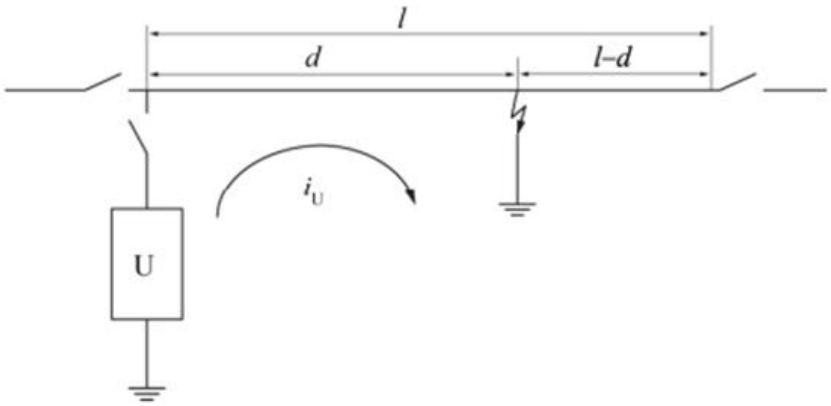

Fig.2. Fault location principle of injection signal method

3.2. Fault location by fault analysis

The basic principle of fault analysis method is: according to the characteristics of fault transient process (such as analytical formula of capacitor discharge stage), the parameters of fault line (inductance or resistance) are calculated, the fault distance is calculated, so as to realize fault location. Because the fault analysis method is based on the transient process of fault, it is generally on-line method. Most fault analysis methods are based on capacitor discharge stage, and some are based on AC side feeding stage.

4. Key Problems in Fault Location of DC Microgrid

Throughout the research status of DC micro grid fault location, the current DC micro grid fault location is in the exploration stage, and the following problems need to be solved.

1) The existence of transition resistance. Transition resistance is a common problem faced by positioning algorithm. The existence of transition resistance will greatly reduce the positioning accuracy. The larger the transition resistance is, the worse the accuracy is. Therefore, the ability of resistance to transition resistance of positioning algorithm is a big index to measure the positioning accuracy. When developing a new fault location algorithm, it is necessary to consider the occurrence of transition resistance fault, and try to eliminate or weaken the influence of transition resistance from the algorithm principle.

2) Accuracy of fault location. The accuracy of positioning is not only affected by the transition resistance, but also by the positioning principle and sampling rate. As far as the algorithm itself is concerned, it is necessary to avoid errors in the positioning principle as much as possible. For example, the problem of calculating the current change rate in reference [36-39], from twice approximation to once approximation, and then to direct measurement, is gradually from the principle. The process of reducing the positioning error. For general algorithms, the sampling rate is directly proportional to the positioning accuracy. The higher the sampling rate, the better the accuracy, but the higher the sampling rate will increase the investment cost. Therefore, when developing a new positioning algorithm, the impact of the sampling rate on the algorithm should be minimized, or the acceptable sampling rate (such as 5KHz) should be used to achieve accurate

positioning.

3) Rapidity of fault location. From the principle of algorithm, compared with the off-line method, the on-line method has better speediness, so the on-line positioning method should be used as much as possible in the situation with high speediness requirements. In addition, the location algorithm generally involves mathematical calculation, which can be used to improve the speed of fault location.

4) Applicability of location algorithm to different types of faults. The applicability of the existing location algorithm is weak, and it can not locate the single pole ground fault and the short circuit fault between poles at the same time. The development of a location algorithm with strong applicability can save the process of fault type discrimination and help to improve the speed of location.

5. Research Prospect of 4 DC Micro Grid Fault Location

Future development direction of DC micro grid fault location is as follows.

1) Select the positioning algorithm based on two terminal measurement, or study the method of estimating fault resistance to eliminate or weaken the impact of transition resistance and improve the positioning accuracy.

2) Limit the change rate and peak value of fault current by optimizing the DC micro grid grounding mode or DC micro grid structure, so as to facilitate the formulation and implementation of fault location algorithm.

3) According to the existing algorithm, develop the composite location algorithm to enhance the applicability of the algorithm, so as to locate the single pole ground fault, the inter pole short circuit fault and even other types of fault at the same time.

4) Adopt the integrated scheme of positioning, control protection and communication, integrate the positioning module in the converter, reduce the scattered positioning device, reduce the investment cost; use the communication system to share the fault location information, and promote the control and protection system to respond in time.

6. Conclusion

In this paper, the fault location principle of DC microgrid is summarized. Firstly, the basic concept of DC micro grid fault location is introduced briefly, and the grounding mode and fault characteristics of DC micro grid and their influence on fault location are analyzed. Secondly, the fault location principle of DC micro grid is classified and studied, and the existing fault location principle is divided into injection signal method and fault analysis method, which means that the existing location algorithm is greatly affected by the transition resistance At the same time, it is impossible to locate single pole ground fault and inter pole short-circuit fault, and there are many factors restricting the accuracy of location. Finally, the key problems of fault location of DC micro grid are analyzed, and the future research on fault location of DC micro grid is prospected.

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