A new fault area search algorithm based on the phase difference of the negative sequence under asymmetric fault in the micro grid

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Abstract. Due to the different fault characteristics of the micro grid under the two kinds of operation mode, which are connected to the main grid and the isolated mode, and the various topological structure and the internal tide make for the traditional relay' malfunction. The paper proposes a fault area localization scheme based on the node searches. The scheme uses the difference of the negative sequence phase of the bus bar feeder terminals as the judgment of the fault direction and then puts forwards a new search scheme for the fault area.

1. Introduction

In recent years, introducing the wide-area protection into the micro grid protection has become one of the major research hot spots. To get the amount of information of each protection installation using communication device and through a certain algorithm to realize the fault area location, the wide-area protection scheme can also be well applied into the micro grid protection. Using wide-area information collection to gradually realize the fault area location has become an important means of overcoming the micro grid protection problems.

As shown in figure 1, a typical micro grid system is connected to 10 kV power distribution network at the PCC point and the condition of the PCC point will determine the micro grid operation mode. The micro power supply, such as wind, solar or gas turbine, is connected into the micro grid through the power electronic devices. The method realizes search of the fault area by collecting information of each bus bar current and uploading the information to the central control unit with the given algorithm processing the information.

2. Criterion of fault direction based on comparison of the negative sequence current phase

2.1 The characteristics of the negative sequence fault component

Due to the MG access, the amplitude and direction of the current in the line will become uncertain.

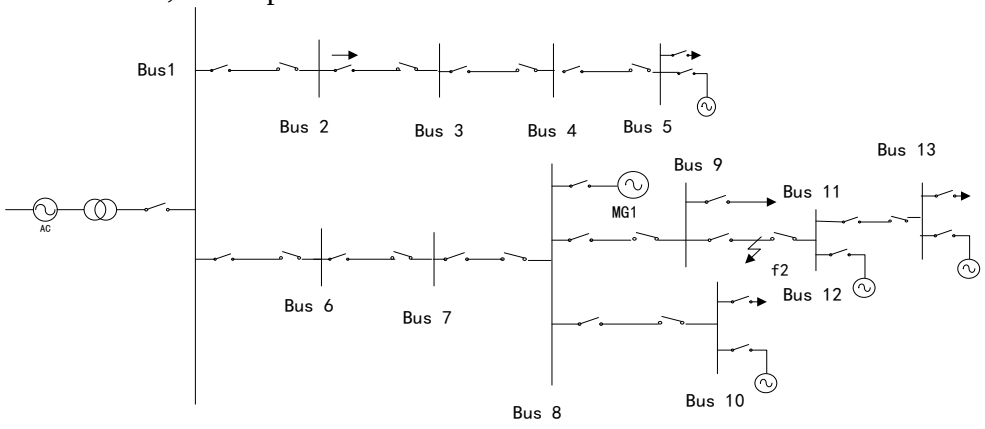

Fig.1 Typical structure of micro-grid

But in the negative sequence and zero sequence networks, the voltage source only exist in the short circuit point getting the direction of the current in one fixed direction when a fault is given. In addition, due to the low voltage grade of the distribution network which the microgrid is connected generally adopt the way of neutral indirectly grounding , the zero sequence is not a reasonable

solution the protection scheme based on negative sequence fault component is more suitable in the micro power grid protection.

2.2 The principle of fault direction judgment

The paper has assumed the positive direction of the current which is from the bus to the line .As shown in figure 2, there is a bus with n (n =3 or higher) branch and an asymmetric short circuit fault occur at the feeder m side f2, which all the circuit component represents the negative component:

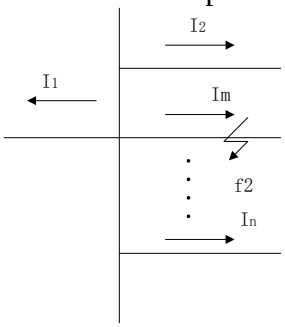

Fig.2 Current condition of the feeder sides when a fault occurs

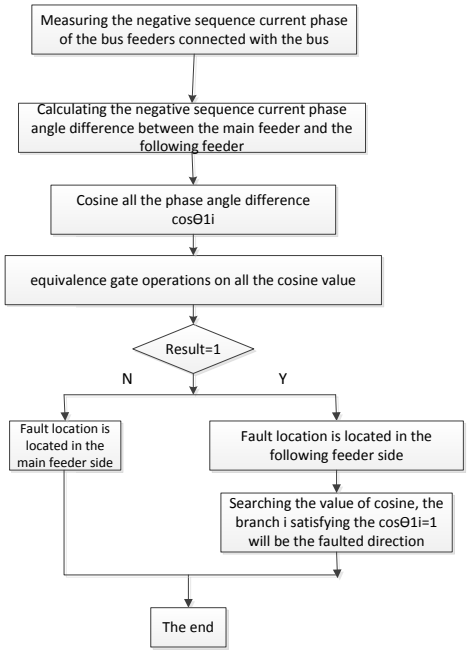

Fig.3 Judging flow chart of the fault direction

According to the Kirchhoff's law:

$$-\dot{I}_m = \sum_{\substack{j=2 \\ j\neq m}}^{n} \dot{I}_j$$

We can conclude from the figure2:

$$-\dot{I}_m = \dot{U}_f \sum_{\substack{j=2 \\ j\neq m}}^{n} \frac{1}{Z_j}$$

$$\dot{I}_j = \frac{\dot{U}_f}{Z_{\Sigma j}}$$

$Z_{\Sigma j}$ represents the negative sequence transfer impedance when taking the side from the bus to the line j; $\dot{U}_f$ represents the negative sequence voltage of the bus when a fault occurs.

In the distribution net, the scope of negative sequence impedance angle is (60°,70°) .In the paper,we take the negative sequence phase of the bus as the reference quantity. As shown in figure 3,

when a fault occurs on the line, the range of the negative sequence current in the fault line is (105,120) and that on the non-fault line is (- 75 °, 60 °).Therefore, we can conclude that the range of the phase angle difference between the non-faulted line is (-15 °,15 °),which is located at the first and the fourth quadrant. The range of the phase angle difference between a non-faulted line and a faulted line is (165°,195°),which is located at the second and the third quadrant .Therefore, a logic judgment using the difference of the ranges to determine the fault feeder side is proposed in the figure 4.

3. Failure area search scheme

In this paper, each bus will be taken as a node. Through fault direction judgment scheme provided above, the bus nodes can be divided into two categories: when the branches of the bus is 2, the fault direction cannot be determined which is defined as the two branch node; when the branches of the bus isabove 2, the fault direction can be determined which is defined as the multiple branch node.

3.1 The typical matrix in the search scheme

In order to get the information of the structure of the microgrid, this paper establishes a structure matrix D_1.

$$D_1 = \begin{bmatrix} d_{11} & d_{12} & \cdots & d_{1n} \\ d_{21} & d_{22} & \cdots & d_{2n} \\ \mathrm{M} & \mathrm{M} & \mathrm{M} & \mathrm{M} \\ d_{n1} & d_{n2} & \cdots & d_{nn} \end{bmatrix}$$

In the matrix, d_{ij}=1,if the node i is connected to the node j or in the situation that the i=j; Otherwise$d_{ij} = 0$,this means the node i is not directly connected to the node j.

As is shown above,the bus node can be divided into two categaries: the two branch node and the multiple branch node. Due to that the searching method will taking different steps in various node,it is necessary to establish a node status matrix to take the corresponding steps. In this paper, the status matrix s is showed below.

$$s = \left[s_1, s_2, s_3, \mathrm{K}\ s_n \right]$$

In the node status matrix, the s_i=1,when the bus node is the multiple branch node and the $s_i = 0$, when the bus node is the two branch node .

To get the direction of the searching steps, two more direction matrix are established, which are respectively to the upper part and the lower part of the matrix structure. The two matrix can determine the search direction of the positive direction and the opposite direction, which we defined the faulted direction of the beginning node as the positive direction. Here are the two direction matrix:

$$D_2 = \begin{bmatrix} d_{11} & d_{12} & \cdots & d_{1n} \\ 0 & d_{22} & \cdots & d_{2n} \\ \mathrm{M} & \mathrm{M} & \mathrm{M} & \mathrm{M} \\ 0 & 0 & \cdots & d_{nn} \end{bmatrix}$$

$$D_3 = \begin{bmatrix} d_{11} & 0 & \cdots & 0 \\ d_{21} & d_{22} & \cdots & 0 \\ \mathrm{M} & \mathrm{M} & \mathrm{M} & \mathrm{M} \\ d_{n1} & d_{n2} & \cdots & d_{nn} \end{bmatrix}$$

3.2 The searching scheme

The first node will be the bus node which is connected to the PCC point .So, the first bus node is defined as the i=1. In addition to this, the nodes are numbered according to the direction of the same branch with following number as is showed in the figure 1.

When a fault occurs in the micro power grid, search steps of fault zone are as follows:

It begins at the node of i=1.

Judging the number s_i in the matrix s: if $s_i = 1$,the search step will go to the node j when the branch j is judged as the faulted direction using the method proposed in the figure 4; if $s_i = 0$,the

method will search structure matrix elementd_{ij} , and gives the value of j to the i and then returns to step 2 to judge again.

Judging the element d_{ij}inD_2: If the $d_{ij} = 1$,the the value of j will be given to the value of i and then the step returns to the step 2. If $d_{ij} = 0$, the element d_{ii} in D_1 will take the operation: $d_{ii} = d_{ii}$+1,and the value of j will be given to the value of i

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Judging the number s_i in the matrix s: if $s_i = 1$,the search step will go to the node j when the branch j is judged as the faulted direction using the method proposed in the figure 4; if $s_i = 0$,the method will search structure matrix elementd_{ij} , and gives the value of j to the i and then returns to step 2 to judge again.

Judging the element d_{ij} inD_3 : if the $d_{ij} = 1$,the search step will go to the step 4; if the $d_{ij} = 0$,the node i satisfying $d_{ii} = 2$ will be tested and the search process is finished.

4. Summary

To locate the fault zone in the micro grid, this paper proposes a fault discriminant solutions as well as a search direction. In this paper, fault direction is distinguished by using the principle of bus bar feeder side phase angle difference and combining with certain logic element. In addition, the paper puts forward three sparse matrix and a column vector matrix and the fault area can be quickly realized through the search of several matrix elements of certain algorithms. Because the matrix put forward in thealgorithm is a sparse matrix and no complex calculation between elements, the storage and computation requirements unitsin the centralized processing of are smaller. In addition, the search scheme also has stronger adaptive ability.

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