비접지 배전계통에서 고장구간 검출 및 복구 알고리즘

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Fault Section Detection Scheme in Ungrounded Distribution System

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Abstract - Fault section detection and service restoration is very important in ungrounded distribution system. Techniques currently used to track down faults are time consuming and cumbersome. A new scheme is developed based on communication technology, and the simulation result shows that the method can satisfy the requirement proposed.

1. Introduction

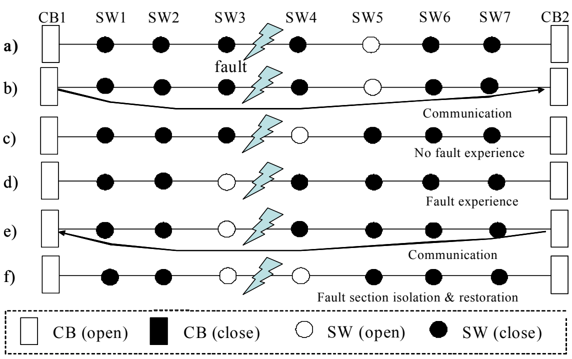
Today, there are many schemes [1] - [5] about fault section detection and restoration in ungrounded distribution system, but a conventional method requires many successive outage invocations to determine a fault section. A communication-based fault handling scheme [6] is given, in this method, the fault section detection and the service restoration can be finished in the same time, it can save much time, and minimize the loss caused by fault. However, it can only solve multi-tie distribution system without loop. This paper do some improvements of the communication-based method, mainly focus on how to deal with the distribution system which contains a loop in it.

2. Communication-based Method

In ungrounded system, more than 75% of the faults are single phase to ground fault. However, the grounded fault in ungrounded system is very hard to detect, because the fault current is very small, it can not be distinguished from system oscillation. So we focus on solving the single phase to ground fault. When fault occurs, it can be detected based on zero sequence voltage easily.

2.1 Single-tie system

Fig.1 shows the operation procedure of proposed algorithm in single-tie distribution system when a fault occurs between switch SW3 and SW4.



<Fig.1> Communication-based scheme in single-tie system

The operation processes are described as the following:
a), fault occurs between switch SW3 and SW4.
b), the feeder with circuit breaker CB1 ask for the information that whether the feeder with circuit breaker CB2 has experienced fault or not.
c), if the feeder with CB2 does not experience fault, the normal open switch moves to the next, then it repeats the previous process.
d), the feeder with CB2 experiences fault.
e), the feeder with CB1 gets the previous information. That means the fault occurs in front of the open switch SW3.
f), fault section is isolated.

2.2 Multi-tie system

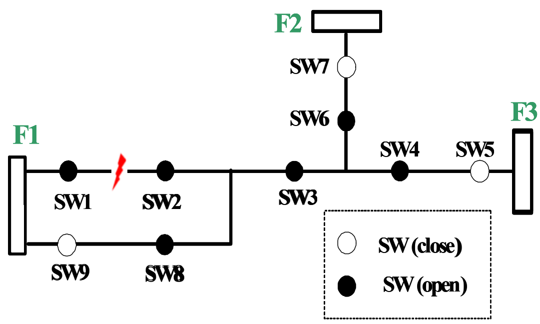
When the method is used in multi-tie system, one more condition should be considered is that we may meet a divergence during the restoration process. In this case, we can compare the remain margin of the two switches beside the divergence point, the one of whose remain margin is lager will continue the restoration.

3. Improvement of the method

Distribution system is very complex, it may contain loops in its topology. At that time, if still use zero sequence voltage as the only criterion, it will not work. Because every point of the loop will detect the zero sequence voltage after a fault occurs.

In order to improve this method, we add one more criterion: zero sequence current. However the zero sequence current is very small in ungrounded system, so only the angle of the zero sequence current is used.

Fig.2 shows a simple distribution system when a fault occurs between SW1 and SW2.



<Fig.2> Simple distribution system

The basic rule is the same with the above.

When fault occurs between SW1 and SW2, feeder1 send fault information to other feeders, if the remote feeder can't detect fault, it begin to restoration by moving the open switch.

Considering the loop, the feeders can be classified into two types, one is feeder with no loop, the other is feeder with loop. At each time we want to move the open switch, three conditions should be considered, and then decide whether it can be moved. The three conditions are: a), RM (remain margin); b), Whether there is a divergence or not; c), The fault information.

3.1 Feeder with no loop (take SW4 as an example)

Assume feeder3 moves the open switch to SW4.
a), Calculate the remain margin, if RM_SW4>0, continue the

restoration, if RM_SW4<0, go back to the previous status: SW5 open and SW4 close, stop the restoration;

b), Judge whether there is a divergence or not, if meet a divergence, compare the RMs of the two switches, when RM_SW4>RM_SW6, feeder3 continue restoration, when RM_SW4<RM_SW6, feeder2 continue restoration; if there is no divergence, it can be ignored.

c), The fault information in this case is zero sequence voltage, if V0=0, no fault can be detected, then continue the restoration, if V0≠0, detect fault, then isolate the fault by open both switches SW4 and SW5.

3.2 Feeder with loop (take SW8 as an example)

Assume feeder1 moves the open switch to SW8.

The first two conditions is the same with the case that the feeder with no loop. However, the last one, the fault information is different. In this case, the fault occurs in the loop, so every where can detect zero sequence voltage, it cannot be a criterion, here zero sequence current's angle is used.

While the open switch is moving across the fault section, the zero sequence current will change its direction. So condition c) can be described as: when V0≠0 and |I0_SW8-I0_SW8'|=180, detect the fault, open both SW8 and SW9, when V0≠0 but |I0_SW8-I0_SW8'|≠180, no fault is detected, continue the restoration.

(I0_SW8' is the zero sequence current's angle before SW8 is opened)

4. Case Study

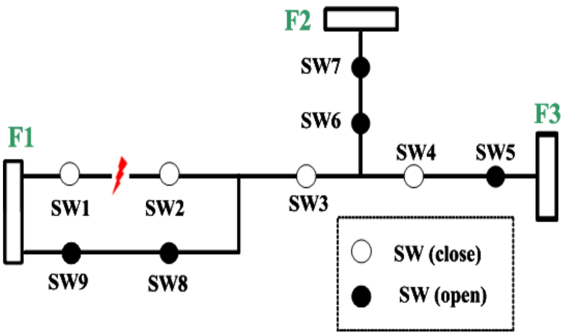
In order to prove the method, we simulate it using MATLAB.

Here we assume the fault occurs at 0.1s, the open switch moves every 0.1s, the remain margin in SW6 is larger than that in SW4, and the relationship between SW8 and SW3 is separated into two cases.

4.1 Case 1:

Feeder1 finish the restoration: (RM_SW3<RM_SW8).

Fig.3 show us the final status after restoration on this condition, and table 1 give us the result of the data.



<Fig.3> Feeder 1 finish the restoration

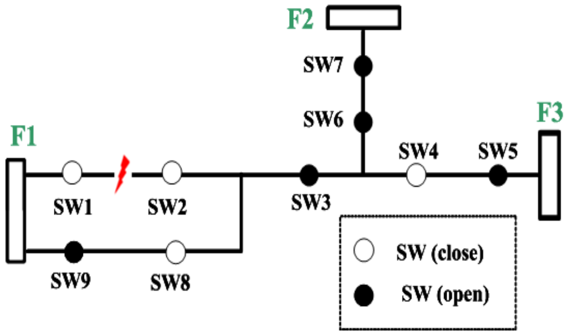
<TABLE 1> Results of case 1:

	Feeder1		Feeder2		Feeder3	
	V0 (mag)	I0 (ang)	V0 (mag)	I0 (ang)	V0 (mag)	I0 (ang)
0-0.1	24.3	----	20.9	----	20.9	----
0.1-0.2	7483	-142.6	22.5	----	22.5	----
0.2-0.3	8159	-146.2	28.6	----	26.5	----
0.3-0.4	8164	-148.3	24.1	----	0.5	----
0.4-0.5	8149	28.6	0.4	----	0.5	----
0.5-0.6	0.3	----	0.3	----	0.4	----

4.2 Case 2:

Feeder2 finish the restoration: (RM_SW3>RM_SW8).

Fig.4 show us the final status after restoration on this condition, and table 2 give us the result of the data.



<Fig.4> Feeder 2 finish the restoration

<TABLE 2> Results of case 2:

	Feeder1		Feeder2		Feeder3	
	V0 (mag)	I0 (ang)	V0 (mag)	I0 (ang)	V0 (mag)	I0 (ang)
0-0.1	15.5	----	3.6	----	3.5	----
0.1-0.2	7408	-140.6	22.5	----	36.6	----
0.2-0.3	8159	-144.2	32.6	----	50.9	----
0.3-0.4	8162	-149.9	36.1	----	0.5	----
0.4-0.5	8165	-150	80.6	----	0.3	----
0.5-0.6	30	100	8660	----	0.3	----
0.6-0.7	0.5	----	2.5	----	0.3	----

The result shows that the method can satisfy the requirement.

5. Conclusion

This improved method gives efficient fault identification and much less outage time than the conventional method. It is the information exchange capability among feeders that could achieve those merits.

Now this method is being put into application using IEC61850 standards as the core communication function.

6. Acknowledgment

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