Research on loop closing operation of hybrid grounding system based on distribution automation

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Abstract. During the loop closing operation, excessive loop current may occur because of the amplitude and phase difference of the busbar voltage on both sides of the loop point, causing overcurrent protection or quick-break protection maloperation. This paper takes the loop closing operation of 10 kV hybrid grounding model of arc suppression coil and low resistance in Hangzhou as an example, use ATP-EMTP software to build the simulation model. The factors affecting the size of the loop current are tested, and the specific conditions for the loop closing operation are determined. The conclusions have great significances for promoting the automatic loop closing operation of 10kV distribution network. The conclusions have great significances for promoting the automatic loop closing operation of 10kV hybrid grounding distribution network.

1. Introduction

With the continuous development of urban power grid, the cable rate and scale of distribution network will continue to increase, which will lead to the increase of capacitance current. The traditional neutral grounding method develops from arc suppression coil grounding to small resistance grounding, so the system will inevitably face the situation of hybrid grounding of small resistance and arc suppression coil. As the daily operation of power system, it is of great significance to study whether the loop closing operation can be carried out under the hybrid grounding system.

The voltage amplitude difference and phase difference between the two sides of the loop closing point, the line load and the total impedance of the loop closing will affect the loop closing current during the loop closing operation. This research takes Hangzhou 10 kV distribution network system as the research object to analyze the influencing factors of the loop current in the loop closing operation. The conclusions have great significances for promoting the automatic loop closing operation of 10kV distribution network[1-5].

2. Simulation Model

Substation A and B are two substations from the same 110kV bus. The neutral point of substation A is grounded through arc suppression coil, and the neutral point of substation B is grounded through small resistance. The system simulation model is shown in Figure 1.
3. Results

The simulation results under different factors are as follows:

3.1 Different Voltage Amplitude Differences of Substation Busbars on Both Sides

When studying the influence of the voltage amplitude difference on the loop current on both sides of the loop point, the lengths of the loop point are 5.1km and 5.6km. In the model, the line load currents on both sides of the loop point are both 300A, simulation analysis are carried out under the condition that the busbar voltage amplitude difference of the substations on both sides of the loop point is 0%, 5%, 7%, 10% and 12%.

The simulation results show that after the 0.2s closed-loop operation, the three phases of the BAC reach the peak value of the loop current respectively in half cycle, and then continue to exist in the form of steady current. The voltage difference between the busbars on both sides of the loop point is increased, which will cause the system loop current and steady-state current to increase. Results are shown in figure 1 and figure 2.

![Figure 1. Grid structure of substation A and substation B.](image1)

![Figure 2. Peak value of phase ABC loop current under different voltage amplitude differences.](image2)
Figure 3. Loop closing steady current under different voltage amplitude differences.

The rated current of distribution circuit breaker is generally 630A, 1000A, 1250A and 1600A, while the rated current of main transformer in A and B substations is 209.9A. After considering the line load, the short-circuit current value and some other factors, the distribution circuit breaker with rated current 630A is selected in actual operation. The maximum current allowed is generally 1.1 times the rated current, that is to say 693A.

From the simulation results, it can be inferred that when the load current on both sides of the closing loop is about 300A and the line length of the two sides of the loop point is 3.983 km and 5.323 km respectively, the steady-state current of the closing loop will not exceed the maximum current allowed 693A of the circuit breaker when the voltage amplitude difference between the buses on both sides of the closing loop is less than 10%, that is to say, the closing operation can be carried out when the voltage amplitude difference is less than 10%. This is consistent with the loop closing operation simulation results of the arc suppression coil system.

3.2 Loop Current under Different 10 kV Line Total Length in the Loop

The total impedance of the loop is another factor that directly affects the loop current, the change in line length will change the loop impedance. In order to investigate the influence of line length on the loop current, the loop point D is taken as the research object, and the total length of the 10kV line in the loop is 10.7km. Set the line load current on both sides of the loop point to 300A, and the line length on both sides of the loop point is shortened from 9.3km to 8km, 6km, 4km, 2km respectively. When the busbar voltage amplitude difference is 5%, the loop current simulation results are shown in the Figure 4.

In the previous section, it is concluded that the line load current is 300A, and the voltage amplitude difference is within 10%, then the loop-closing operation can be carried out. However, special consideration is needed for the closed-loop problem of the shorter line. For example, when the sum of the lengths of the lines on both sides of the loop is about 2 km, the loop steady current exceeds the rated current of the circuit breaker, so the voltage amplitude difference needs to be adjusted to within 5% to perform the loop operation.
3.3 Simulation Results of the Outgoing Line of the Arc Suppression Coil Grounding System to the Small Resistance Grounding System

The simulation results show that if the loop is closed when the single-phase grounding fault occurs in the system, the whole loop has the characteristics of single-phase grounding. Therefore, the zero sequence current protection device of the small resistance grounding system will operate when the outgoing line of arc suppression coil side closes the loop to the small resistance side through the loop closing operation, and the loop closing operation failed.

4. Conclusion

The difference between loop closing operation of hybrid grounding system and arc suppression coil system is that when loop closed under single-phase grounding fault condition, the hybrid grounding system generally does not operate the loop closing operation from the side of small resistance to the side of arc suppression coil.

The simulation results of loop closing operation between hybrid grounding system and arc suppression coil system are basically the same.

Under normal circumstances, the bus voltage amplitude difference between the two sides of the loop point should be controlled within 10% to allow the loop operation; The decrease of the line length in the closed loop will increase the loop current. For the loop operation of about 2km line, the voltage amplitude difference needs to be controlled within 5%.

References

[1] M. Mitolo, "Grounding the Neutral of Electrical Systems Through Low-Resistance Grounding Resistors: An Application Case," IEEE Transactions on Industry Applications, vol. 44, no. 5, pp. 1311-1316, 2008.
[2] Y. D. Gao, D. U. Bin, F. Zhao, and W. Shi, "Study on the Arc-grounding Overvoltage in the Distribution System with Neutral Point Grounded through Low-resistance," High Voltage Apparatus, 2004.
[3] J. C. Tobias, F. Sautriau, D. J. Hull, and S. Fabray, "Improved quality of supply in MV distribution networks using directional blocking scheme," in Electricity Distribution, 2002.
[4] R. P. Leeuwerke, A. L. Brayford, A. Robinson, and J. C. Tobias, "Developments in ring main unit design for improved MV network performance," Power Engineering Journal, vol. 14, no. 6, pp. 270-277, 2000.
[5] K. Y. Shen and J. C. Gu, "Protection coordination analysis of closed-loop distribution system," in International Conference on Power System Technology, 2002.