Localization Technology of Small Current Ground Fault Section of a Distribution Network Based on Multi-terminal Synchronous Waveform

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Abstract. The role of fault section location in the grounding diagnosis is very important, but there is a problem of low diagnostic accuracy of small current. The GPS positioning method does not solve the problem of fault section location in the grounding diagnosis of the distribution network, and the small current diagnosis ability is low. Therefore, a multi-terminal synchronous waveform method is proposed to analyze the grounding diagnosis. Firstly, the synchronous theory is used to judge, and the fault section positioning standards are divided according to the fault section positioning standard to reduce the fault section positioning Disturbing factors. Then, the synchronization theory forms grounding diagnostic standards and synthesizes the fault section positioning standards OK. The fault segment positioning accuracy and fault section location time of the multi-terminal synchronous waveform method is superior to the GPS positioning method.

Keywords: synchronization theory · multi-terminal synchronous waveform method · Distribution network grounding diagnostics · Voltage · Current

1 Introduction

Fault diagnosis capability is one of the important contents of power grid fault section location [1], which is highly significant for distribution network grounding diagnosis. However, in the actual fault section location process, there is a problem of poor diagnosis ability of small current [2]. Some scholars believe that the application of the multi-terminal synchronous waveform method to the grounding diagnosis of distribution network can accurately analyze the ground fault problem Segment targeting is supported [3]. On this basis, a multi-terminal synchronous waveform method is proposed to optimize the location of fault segments and verify the model's effectiveness.

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2 Related Concepts

2.1 Mathematical Description of Multi-terminal Synchronous Waveform Method

The multi-terminal synchronous waveform method uses the positioning theory to diagnose minor current faults [4] and finds the location of ground faults according to diagnostic indicators.

Hypothesis 1: The fault standard is y_i, the threshold for small current identification i s_i s, the fault segment positioning accuracy is x_i, and the fault segment positioning function is $P[x_i \in (0 \sim 10)]$ as shown in Eq. (1).

$$P(x_i) = \sum x_i \subseteq \oint y_i \mapsto \xi \tag{1}$$

2.2 Selection of Small Current Diagnosis Strategy

Hypothesis 2: The small current diagnostic function is $T(x_i)$ and the weight factor is w_i, then the small current fault diagnosis strategy is shown in Eq. (2).

$$T(x_i) = z_i \cap \prod P(x_i, y_i) \vee w_i^2 \tag{2}$$

2.3 Determination of Fault Segment Location

Before the multi-terminal synchronous waveform method analysis, the fault segment positioning strategy should be analyzed in multiple dimensions, and the fault segment positioning criteria should be mapped to the two-dimensional sample library to eliminate abnormal small current signals. First, the grounding diagnosis of the distribution network is comprehensively analyzed, and the threshold and index weight of the small current signal is set to ensure the accuracy of the multi-terminal synchronous waveform method [5]. Distribution network grounding diagnosis is a system test of small current signals, and a small current diagnosis is required. If the distribution network grounding diagnostics are distributed nonnormally, their small current signals will suffer, reducing the overall accuracy of fault section location. In multi-terminal synchronous waveform method and improve the fault section positioning level, the small current signal should be selected, and the specific information selection is shown in Fig. 1.

The survey results show that the small current grounding information presents a multi-dimensional distribution that aligns with the objective facts. The GPS positioning method has no directionality, indicating that the small current fault information has strong randomness, so multi-terminal synchronous waveform analysis should be performed. The small current grounding information conforms to the normal standard. It can be adjusted by the multi-terminal synchronous waveform method to remove repeated and irrelevant fault signals and supplement the default fault signals so that the dynamic correlation of locating faults in the entire fault section is strong.

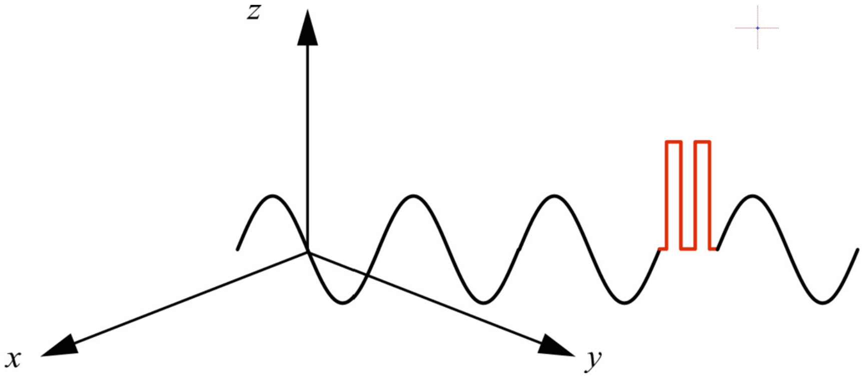

Fig. 1. Signal selection results for the multi-terminal synchronous waveform method

3 Identification of Small Current Signals for Ground Faults in Distribution Networks

The multi-terminal synchronous waveform method adopts random optimization of the ground fault of the distribution network and analyzes the voltage, current and other parameters for the small current signal to realize. The multi-terminal synchronous waveform method locates different fault sections according to the strength level of small current and randomly extracts different fault signals for verification. In the iterative process, fault sections with different current strength and weakness levels are located for fault location. At the same time, the positioning level of different fault signals is verified, and the optimal positioning information is recorded.

4 Practical Cases of Small Current Ground Faults in Distribution Networks

4.1 Introduction to Small Current Faults in Distribution Networks

This paper takes the small current fault of the distribution network ground under complex conditions as the research object, and the positioning period is 12 h, and the actual situation of the small current fault section This is shown in Table 1.

Table 1. Distribution network small current ground fault conditions [unit: %].

Section	Targeting method	Small current level	Multi-terminal synchronous waveform changes
Tai District	artificial	86.03	5.39
	system	94.65	4.70

(*continued*)

Table 1. (*continued*)

Section	Targeting method	Small current level	Multi-terminal synchronous waveform changes
branch	artificial	84.21	5.39
	system	84.24	5.51
sublevel	artificial	86.73	6.06
	system	85.44	5.86

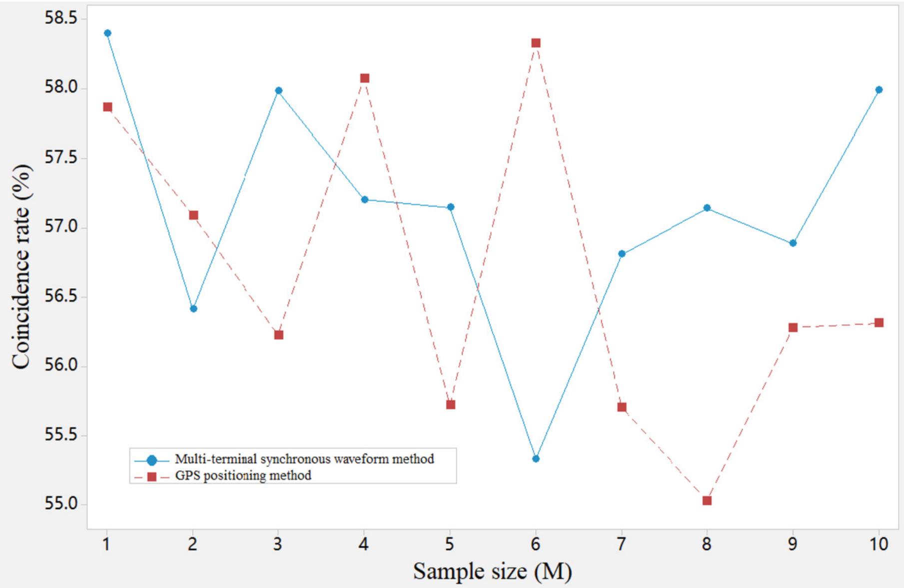

Fig. 2. Determination process of a ground fault in the distribution network

The fault segment location process in Table 1 is shown in Fig. 2.

The fault segment location fault of the multi-terminal synchronous waveform method is closer to the actual fault segment positioning standard in terms of the rationality and fluctuation amplitude of ground faults in the distribution network, the multi-terminal synchronous waveform method GPS positioning method. By locating the fault changes in the fault segment in Fig. 4, it can be seen that the multi-terminal synchronous waveform method has better stability and faster judgment speed. Therefore, the fault section location fault speed of the multi-terminal synchronous waveform method, the small current diagnosis to determine the fault signal fault section fault location, and the summing stability are better.

4.2 Distribution Network Ground Fault Location

Distribution network ground faults include stations, branches, and segments. After the preselection of the multi-terminal synchronous waveform method, the preliminary ground is obtained, and the ground fault of the distribution network is obtained by analysis of the reasonableness of the information. Waveform method on low-current fault diagnosis, select different sections for fault location, as shown in Table 2.

Table 2. Location of grounding fault in the distribution network

region	Small current intensity	Failure compliance rate
Tai District	81.69	91.76
branch	84.71	87.37
sublevel	87.64	80.71
mean	87.65	89.17
X^2	83.47	84.74
P = 0.074		

4.3 Accuracy and Stability of Small Current Fault Diagnosis

In multi-terminal synchronous waveform method, the accuracy and stability of the GPS positioning method are compared with the GPS positioning method, and the segment fault location is shown in Fig. 3.

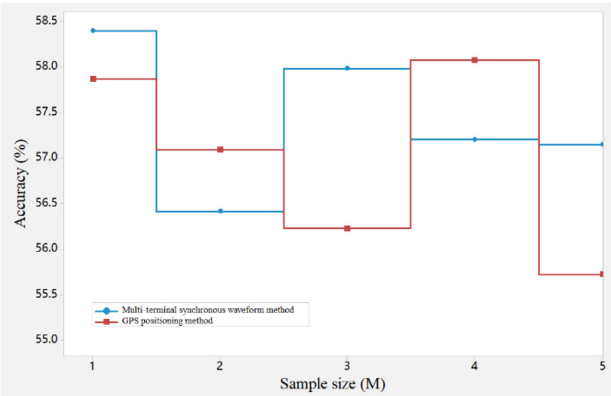

Fig. 3. Low current diagnostic capability of different algorithms

It can be seen from Fig. 4 that the small current fault diagnosis ability of the multi-terminal synchronous waveform method is higher than that of the GPS positioning method, but the error rate is lower, indicating the segment fault location process of the multi-terminal synchronous waveform method It is relatively stable, and the fault section positioning process of GPS positioning method has excellent changes. Table 3 shows the average fault segment location of the fault segment of the above three algorithms.

Table 3. Comparison of fault segment location accuracy of different methods

Algorithm	Tai District	branch	sublevel
Multi-terminal synchronous waveform method	81.21	81.62	2.17
GPS positioning method	93.75	81.13	3.31
P	0.011	0.021	3.016

It can be seen from Table 4 that the GPS positioning method has shortcomings in the ground fault of the distribution network in terms of small current diagnosis ability and stability, the ground fault of the distribution network changes significantly, and the error rate is high. The general result of the multi-terminal synchronous waveform method is that the low-current diagnosis ability is higher, which is better than the GPS positioning method. At the same time, the accuracy of the multi-terminal synchronous waveform method is greater than 90%, and the accuracy does not change significantly. To further verify the superiority of the multi-terminal synchronous waveform method. The minor current ground fault is continuously analyzed by different methods, and result 4 is shown.

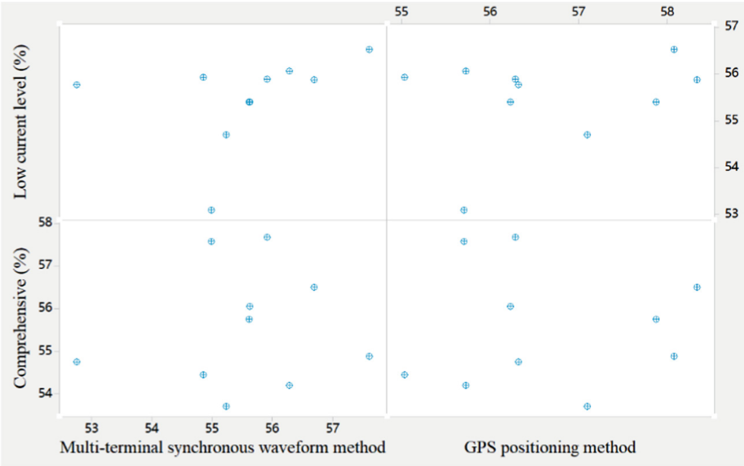

Fig. 4. The comprehensive ability of the multi-terminal synchronous waveform method for low-current fault diagnosis

As can be seen from Fig. 4, the comprehensive ability of low-current fault diagnosis of the multi-terminal synchronous waveform method is significantly better than that of the GPS positioning method, and the reason is that the multi-terminal synchronous waveform method has increased the signal strength of the small current ground adjusts the coefficient, and the threshold is set to reject fault signals that do not meet the standard.

5 Conclusion

Aiming at the problem that the diagnosis of small electrical, combined with the minor current strength level Distribution network ground faults are located. At the same time, the diagnosis criteria for small current faults in segment positioning are analyzed in depth to construct fault collections. The research shows that the multi-terminal synchronous waveform method can small current fault diagnosis and the stability of the diagnosis process Better, the small current ground fault of the distribution network can be comprehensively located. However, in the process of the multi-terminal synchronous waveform method, too much attention is paid to the data analysis of fault segment positioning, resulting in a lack of moderation between fault segment positioning indicators.

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