Research on Intelligent Detection Technology of Short-term Flashover Fault in High-Power Main Network Power Systems

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Abstract. Traditional detection techniques are affected by surrounding factors and cannot accurately determine the location of the fault point. In order to solve the problem, a short-term flashover fault intelligent detection method in the paper is proposed for high-power main network power system. The short-term flashover fault feature of the high-power main network power system is extracted by the wavelet-type wavelet packet energy moment. The CPRS networking mode is used to intelligently detect the short-term flashover fault of the high-power main network power system. Experiments show that the proposed technique is more accurate than traditional detection techniques.

1. Introduction
As the number of cables increases and the running time increases, the probability of failures increases. In order to find the cable fault point, the high-power main network power system is used to ensure unimpeded power supply. However, due to the concealment of the cable line, it will be interfered by various environmental factors, which brings a lot of troubles to the fault finding. Although the traditional fault intelligent detection technology can quickly determine the location of the fault point, it will be affected by the weather, which can cause system failure [1]. In order to solve the problem, a short-term flashover fault intelligent detection method in the paper is proposed for high-power main network power system.

The short-term flashover fault intelligent detection technology of high-power main network power system can divide the short-term flashover fault of the system into several fault types according to the resistance and the breakdown gap. According to the cable fault, it is divided into low resistance, high resistance and flashover failure, and the cable flashover fault in the paper is analyzed. The main cause of flashover failure is that the cable is well insulated at low voltages, but when the voltage rises to a certain value, the voltage will instantaneously breakdown. Therefore, an intelligent detection technology is proposed for the short-term flashover failure of high-power main network power system.

2. Design of intelligent detection technology for short-term flashover fault of high-power main network power system
2.1. Feature extraction of short-term flashover faults in high-power main network power system
According to the theoretical basis analysis of the short-term flashover fault of the high-power main network power system. Firstly, the system single-phase ground fault is within 10, the transient capacitance current determination determines the assignment and frequency of the transient ground current; in order to reduce the probability of system failure, the feature quantity extraction of the transient ground current signal is required. When the charge-discharge between the system and the
ground capacitance is greater than the steady-state base, the transient high-frequency component is significantly higher than the steady-state signal, which is the main cause of the system’s short-term flashover failure [2]. Secondly, in the short-term moment of the failure, the arc-suppression coil will multiply, which can result in the transient high-frequency current being affected by the arc-suppression coil at the moment of the failure. Therefore, the short-term flashover fault feature of the high-power main network power system is extracted by the coil-type wavelet packet energy moment, and the following definition is made. If the signal \( x(t) \in L^2(\mathbb{R}) \) is set, the convolution-type wavelet packet transform form is:

\[
x_p = \frac{1}{\sqrt{2}} \sum_{k} h(k) x + \frac{1}{\sqrt{2}} \sum_{k} g(k) x
\]

(1)

Where \( h(k) \) and \( g(k) \) represent filter coefficients, \( x \) represents decomposition scale, and \( P \) represents frequency band number. The formula (1) is applied to shift the decomposition result of the previous scale, and then the sequence length and the original signal of each frequency band in each layer are processed, so as to solve the problem that the decomposition signal samples of different decomposition scales increase with the decomposition scale. Finally, the fault amount is extracted by the energy envelope of the model wavelet packet. Assuming that the original sampled signal is \( w \), \( B \) is the total number of sampling points, and \( v \) is the number of decomposition layers, then the signals of each frequency band are:

\[
w_{ij} = \sum_{k=1}^{v} k |v \cdot B|
\]

(2)

Step2: Constructing a feature vector. When the system fails, it will have a greater impact on the energy moment of the short-term flashover signal. Therefore, it is necessary to construct a normalized feature vector in the energy moment, and the feature vector is:

\[
F = [w_1, w_2, ..., w_n] / \sum_{k=1}^{v} w_{ij}
\]

(3)

Where \( F \) represents a feature vector. The feature vector [3] of short-term flashover failure of high-power main network power system is obtained by using formula (3).

Step3: The feature vector is input into the wavelet neural network for fault location.

2.2. Realizing short-term flashover fault intelligent detection of high-power main network power system

After extracting the short-term flashover fault of the high-power main network power system, the characteristics of the flashover fault need to be classified, as shown in Table 1.

| Fault nature | \( R_i \) | Definition |
|--------------|-------------|------------|
| open circuit | \( \infty \) | Breakdown under the action of DC or high voltage pulses |
| low resistance | \( <10Z_o \) | High voltage pulse breakdown can be used when the \( R_i \) is not very low |
| high resistance | \( <10Z_o \) | High voltage pulse breakdown |
| flashover | \( \infty \) | DC or high voltage pulse breakdown |

The characteristics of short-term flashover faults of high-power main network power systems are classified according to Table 1. Generally speaking, the probability of occurrence of single-phase ground faults will be higher, which account for about 80% of the total number of faults [4]. The other two short-circuit faults account for about 10%. The next two-phase short-circuit fault is relatively small, which is
about 2%. In comparison, the fault range of the flashover fault is wider, which is likely to cause system failure, and if it is serious, it will also affect the system power supply. Therefore, it is necessary to determine the severity of the system's short-term flashover fault through fault intelligent detection, so that the tester can maintain it in time [5].

In the design of the paper, the CPRS networking mode is used for networking in multiple modes. Its networking mode can meet the application requirements of different occasions and can effectively solve the interference of reducing the surrounding environment [6]. Using point-to-point data transmission, Figure 1 shows that the short-term flashover fault detection process for high-power main network power systems.

![Figure 1. Short-term flashover fault intelligent detection process for high-power main network power system](image)

The point-to-point transmission mode of Figure 1 is used to intelligently detect short-term flashover faults in the high-power main network power system. Firstly, the data measured by the high-power main network power system is processed. After the fault point distance information is obtained, the port of the measurement system is communicated, and the data is transmitted to the network for transmission. GPRS only supports one-to-many data transmission mode, so in the process of detection, the detection center can manage several fault feature quantities, but it needs to be detected by multiple power cables [7].

Secondly, intelligent detection should be carried out according to the characteristics of the system's short-term flashover failure. The fault location methods corresponding to different fault types are different. In order to accurately determine the point, it is necessary to first transfer the load on the non-faulty power loss area to other feeders, and formulate a fault recovery scheme that meets the optimized comprehensive index.

Finally, when the system is powered on, the server needs to set the communication port number for intelligent detection and receive the client's request. When the client is powered on, it will be connected to the server. If the connection is successful, the system can be intelligently detected from another port [8]. The degree of intelligence of the technology is relatively stable. Since the system is subject to harsh environment interference and causes serious difficulties in actual operation, it is necessary to find an accurate fault specific location according to the fault feature quantity. The technology overcomes the defect that the traditional detection technology uses a part of the cable as a test object, and can increase the reliability and rationality of the test result. In the event of a system failure, the client can be informed of the operating status of the system and early detection of problems. Thus, the design of the short-term flashover fault intelligent monitoring technology for the high-power main network power system is completed.
3. Experiment analysis
In the experiment, in order to verify the application value of short-term flashover fault intelligent monitoring technology for high-power main network power system, the traditional detection technology is set as the control group by using the numerical comparison method, and the short-term flashover fault intelligent monitoring technology of the high-power main network power system is set as the experimental group to verify the effectiveness of the proposed method.

3.1. Experimental environment
The test environment is shown in Figure 2.

![Figure 2. Experimental environment](image)

3.2. Experimental parameters
During the test, the two detection techniques are tested and three typical test signals are selected, as shown in Table 2.

| Decomposition layer | $k = 1$ | $k = 2$ | $k = 3$ | $k = 4$ |
|---------------------|--------|--------|--------|--------|
| Blocks signal ($db$) | 19.2654 | 19.5643 | 20.2654 | 15.2659 |
| Bumps signal ($db$) | 18.5694 | 18.2565 | 19.5648 | 13.2658 |
| Heavysine signal ($db$) | 10.2654 | 18.5693 | 16.2659 | 16.2659 |
|                     | 16.2589 | 14.2665 | 19.2651 | 14.2658 |
|                     | 16.2635 | 18.2665 | 19.6321 | 16.2648 |
|                     | 18.5923 | 21.1659 | 18.2654 | 13.2654 |

3.3. Experimental results
The comparison of the accuracy of the two detection techniques is shown in Figure 3.
Figure 3. Experimental comparison result

It can be seen from Fig. 3 that the intelligent detection technology designed in the paper is better in decomposing the detection effect of different layers. It can be seen from the comparison chart that the high-power main network power system has a higher accuracy in the short-term flashover fault intelligent detection technology. The traditional detection technology will be disturbed by the surrounding environment, which can result in reduced accuracy of the test results.

In summary, the accuracy of the short-term flashover fault intelligent detection technology of the high-power main network power system is more popular than the traditional detection technology.

4. Conclusion
Aiming at the shortcomings of traditional detection technology, a short-term flashover fault intelligent detection technology in the paper is proposed for high-power main network power system and the wavelet decomposition scale is applied to reduce the negative effects produced by the decomposition layer. Finally, the technical design of this paper is more accurate by experimental demonstration.

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