Fault Phase Selection Method based on series Multi-Resolution Morphological Gradient

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Abstract. AS for the protection of electric transmission lines, to achieve fast and correct selection of the fault phases is helpful to secure the sensitivity and reliability of the protection, which also guarantees the right operation of single-phase tripping and single phase reclosing. The traditional phase selection algorithms are conducted upon industrial frequency variable. The sensitivity of the method would be affected by the fault resistance, fault location, adjacent mutual inductance, and the lack of reactance effect, system parameters and other reasons. This paper has applied series multi-resolution morphological gradient (SMMG) filter to extract industrial frequency variable of the mode current, which constructed a new mode fault component phase selection element, and provided a new way of thinking for fault component phase selection.

Keywords: mathematical morphology; morphological gradient; SMMG; mode current; fault phase selection

1 Introduction

At present, the domestic method for microprocessor transmission line protection is mainly conducted by combining prompt phase selection and static phase selection, which applies the current difference prompt element as the primary phase selection element after protection starting, and applies subarea phase selection of sequence current as the phase selection element in fault shift and successive operation protection. However, it has been detected that sequence component phase selection element may conduct malfunction in phase selection as for the fault in oscillation link under certain situation [1]. The traditional phase selection algorithms are conducted upon industrial frequency quantity. The sensitivity of the method would be affected by the fault resistance, fault location, adjacent mutual inductance, and the lack of reactance effect, system parameters and other reasons. Aiming at the problem, some new technologies have been applied in fault phase selection. Traveling-wave is one of the common methods, while this algorithm may require high level of hardware protection devices and in addition, though as a high frequency signal it could not be separated from noise. Wavelet transform has been applied in fault identification and

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phase selection as a terrific trait extraction tool in recent years. In order to obtain pleasing effect, wavelet filter with longer wave and multi-layer wavelet decomposition should be conducted to the signal which may induce longer processing time and is not profitable for rapid protection requiring strong real-time property.

Aiming at the problem of phase selection element and algorithm, this paper has applied the series multi-resolution morphological gradient (SMMG) filter to extract industrial frequency variable of the mode current, which constructed a new mode fault component phase selection element, and provided a new way of thinking for fault component phase selection.

2 Mathematical morphology and the gradient

2.1 Mathematical morphology (MM)

Defining f(x) as the one-dimension input signal within the fields of $D_f \subseteq E$, g(x) as the constructional element within the fields of $D_g \subseteq E$. The expansion and corrosion parameter can be obtained by the formula below:

$$(f \oplus g)(x) = \max\{f(x-y)+g(y)\} \tag{1}$$

$$(f \Theta g)(x) = \min\{f(x+y)-g(y)\} \tag{2}$$

It can be seen from the formula above that the obtaining of parameters is quite easy with calculation of plus and minus excluding multiplication and division which provides high speed and minimum time delay[2].

2.2 Multi-resolution morphological gradient transformation (MMG)

Multi-resolution morphological gradient transform (MMG) is a technique designed for power system electromagnetic transient signal. In the multi-resolution morphological gradient techniques, a flat structural element which is variable and has a different origin location is defined as bellows:

$$g^{+} = \left\{g_1, g_2, \cdots g_{l-1}, \underline{g_l}\right\} \tag{3}$$

$$g^{-} = \left\{\underline{g_1}, g_2, \cdots g_{l-1}, g_l\right\} \tag{4}$$

Where, g+ and g- are applied to extract for up and down edge of the wave[3].

Theoretically speaking, the correct combination order of its cascade structure elements could be found; any weak signal changes can be detected by applying SMMG. The length of the structure elements and cascading order selection in SMMG is not yet supported by a complete theoretical basis; the primary means is heuristics. The SMMG filter designed in accordance with the principles can conduct a simulation of the existing signal samples, and then determine the sensitivity and reliability to meet the requirements, the shortest length of which may act as the practical filter[4].

3 The new phase selection method based on SMMG and mode fault component

3.1 Phase selection element for mode fault component

The current, voltage obtained when the system encountered any type of fault can be decomposed into a non-fault component and the fault component. According to the principle of superposition, the fault component in the system of the fault point can be solved as the equivalent power by superposition [5]. By the linear transformation theory, it has shown that the module components can be used to analyze fault component network [6]. Each module are independent of each other, so when the modulus equivalent power is deduced from fault boundary conditions, the independent network of each module can be obtained in order to get the fault components.

3.2 Phase selection algorithm

Conduct a design of $SMMG_2^3 \times SMMG_4^1$ filter with a sample rate of 1.8 kHz to extract industrial frequency variable of the mode current. The structure of phase selection element is shown in Figure 1.

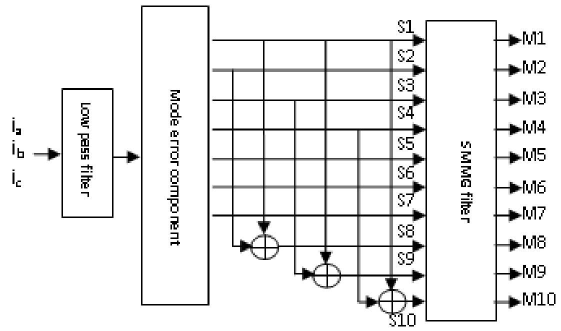

Fig. 1. Block diagram of the phase selection.

The output value Mi, i = 1,2, ..., 10 is shown in the figure, and the characteristic patterns is shown in Table 1. Where, "1" represents the occurrence of an apparent mode extremum in SMMG coefficients; "0" represents no such value. Characteristics shown in the table can be used to form the fault phase selection element.

4 Simulation

EMTP is applied to establish a 500KV simplified system diagram of UHV transmission lines, the structure is shown in Figure 2. The length of transmission line is 300km， and the structure parameter is shown as bellows:

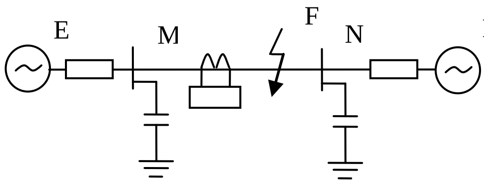

Fig. 2. Ultra high voltage transmission line system.

$R_1 = 0.024\Omega / km$, $X_1 = 0.27\Omega / km$, $R_0 = 0.223\Omega / km$, $X_0 = 0.87\Omega / km$, $C_0 = 0.0082uF / km$.

5 Conclusion

This paper has applied SMMG filter to extract industrial frequency variable of the mode current, which constructed a new mode fault component phase selection element. The research results of theoretical and experimental has indicated that this element embraces a characteristics of rapid response and sensitivity neglecting the influence of load current, and the influence of power impedance and fault timing is very low. The algorithm of this phase selection element is quite easy with lower hardware requirements, which is ripe to conduct development under current hardware, and it has great application value and broad prospects.

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