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METHOD OF CALCULATION OF CURRENT OF THE GROUND FAULTS IN THE PARALLEL OVERHEAD TRANSMISSION LINES 110-220 KV

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Abstract. The mutual induction between the phase wires of the different overhead lines which situate close to each other cause unbalanced redistribution of currents in the line wires. This leads to emergence of the out-of-balance zero sequence current which affects negatively on the sensitivity of the zero-sequence current protection. It is impossible to estimate such out-of-balance current by the means of the typical calculation programs for short circuit currents. This paper describes the method of "virtual" lines for an extra correction of the values of zero-sequence currents during the current ground faults happening in the overhead lines 110-220 kV. There is an example of using this method for three parallel overhead lines 220 kV passing close to each other.

1 Introduction

In the multiended overhead lines 110-220 kV which include multiwire overhead parallel line (OHPL) and OHPL with single or several branches there is a problem of taking in account the zero-sequence current while adjusting sensitive stages of zero-sequence current protection[1]. This problem exists because of the high out-of-balance currents in the lines as much as in normal operating conditions and during the remote asymmetrical short-circuits which happen by the reason of mutual induction between phase wires of one line or two separate lines. In these circumstances the values of currents and the distance between the wires play an important role [2]. In the much loaded OHPL such influence might cause zero-sequence currents of several dozens of amperes [3]. Out-of balance currents are approximately the same as the currents in the set points of sensitive functions (zones) of zero-sequence current protection. The set points are put out functioning to avoid their false work and the reliability of backup is reduced.

The zero-consequence out-of-balance currents result the great difference between the real and calculated short-circuit currents of single-phase short circuits while using typical calculation programs [4].Finally, there is a requirement to accept set points of protection with a large safety factor to exclude non- selective operation, but sensitivity of protection is reduced.

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2 Experimental setup and study technique

To consider the influence of the mutual induction of the triple-circuit transmission line on the phase currents flowing in it while fault regime the part of a network represented in the Fig. 1 has been taken for analysis. It has three parallel OHPL: W1, W2, and W3.

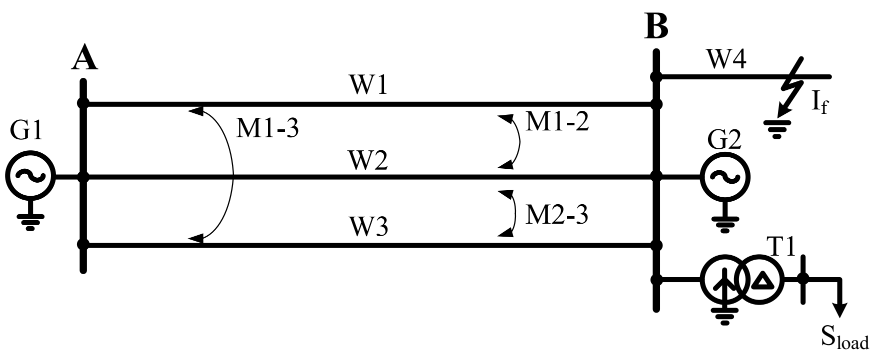

Fig. 1. Network scheme.

The section consists of three OHPL which go close to each on the same routingand have the start points at one substation and the end points at another substation. This makes it possible to consider them as triple circuit line. All the lines have a metal lightning arrester grounded on each tower. Every line is divided for 7 segments where the distance between the wires is different.

According to the analysis implemented with the program of calculation of the short-circuit currents in electric Power Networks RTKZ 2.03 [5], for unbalanced conditions caused by ground short circuit of one of the phases of considered OHPL,there is no required accuracy in values of short-circuit currents because they do not correspond to those which were registered by recording emergency instrument at the fault moment. The essential of the main obstacle to achieve the needed result is the absence of an opportunity to set mutual induction between separate phases and impossibility to take into consideration the affection of grounded wire hawsers and unbalanced conditions of the load. These limits can be eliminated by the application of extra methods for more precise definition of the parameters of conditions.

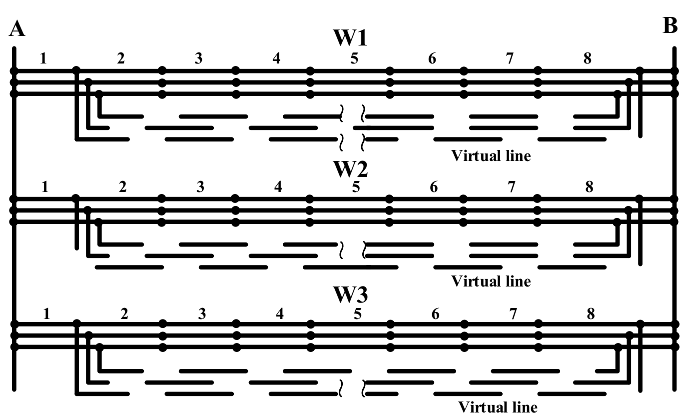

Fig. 2. An explaining scheme of the lines having three “virtual” ones to simulate an asymmetry.

The inherent and mutual resistances of the equivalent circuit have been calculated during the research based on the geometrical parameters of the lines.

It is offered to set the “virtual” lines to simulate the asymmetry caused by the mutual induction between not only the separate circuits (equivalent wires of circuits) but separate phase wire of the single line. In Figure 2 there is an explaining scheme of the lines having three “virtual” ones.

The resistances of “virtual” lines are calculated by the following method. For example, let us assume that $I_A > I_B > I_C$. In this case it is needed to set two parallel lines with the simulation of the open-phase mode in the line №1 (the failure of the phases B and C) and in the line №2 (failure of the phases A and C). The resistance of an extra line №1 z_{wi1} in the base of the main line can be defined the following way:

$$z_{wi1} = \frac{I_{wiA}}{I_{wiA} - I_{wiC}} \cdot z_{wi}, \tag{1}$$

$I_{wiA,B,C}$ - phase currents of the main line W_i

$$z_{wi2} = \frac{I_{wiA}}{I_{wiA} - I_{wiB}} \cdot z_{wi}, \tag{2}$$

z_{wi2} - the resistance of an extra line №2.

There also can be the mutual induction between the main circuit W_i and “virtual” lines W_{i1} and W_{i2}.

Thus, two “virtual” lines must be set in parallel of each line.

There is another way of setting the “virtual” lines according to it one “virtual” line is set in parallel to basic line. The resistances of the “virtual” lines are defined by the means of the following method:

The phase with the most current $I_{wi\max}$ is defined;

Then the resistance of the “virtual” line z_{wi1} connected to this phase is defined according to the following formula:

$$\begin{aligned} z_{wi1}^{(1)} &= \frac{I_{wi\max}}{I_{wi}^{0}} z_{wi}^{(1)}, \\ z_{wi1}^{(0)} &\approx z_{wi1}^{(1)} k, \end{aligned} \tag{3}$$

$z_{wi1}^{(1)}$, $z_{wi1}^{(0)}$ -resistance of the direct and zero sequence of the “virtual” lines;

$z_{wi}^{(1)}$ - resistance of the direct sequence of the main line; k=3÷4.

3. Two phases with the minimal current are switched off.

The currents have been calculated using the method confirm its efficiency because the error of the calculation is not more than 10 % meanwhile without using the method described above it might be about 20-30 %.

3 Conclusion

Thus, the proposed method to define the parameters of the "virtual" lines with the program RKTZ 2.03 which allows to calculate the modes of the network having numerous longitudinal-transversal asymmetries and the load lets to simulate the affect of the line's own mutual induction between the wires "phase-to-phase" and "phase-to-wire-lightning arrester" and of mutual induction of neighbouring circuits. At the same time, it allows to calculate accurately for the relay protection (10 % of error) the distribution of the zero-sequence currents (phase currents) of the lines having significant mutual induction between circuits in the load-mode, which is hard to achieve by the means of the typical programs used in Russia to calculate the short-circuit currents.

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