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A combined impedance and traveling wave based fault location method for multi-terminal transmission lines

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ABSTRACT

A new fault location method suitable for multi-terminal transmission lines that combines the advantages of both impedance and traveling wave based methods has been developed and presented in this paper. The proposed method first determines whether the fault is grounded or ungrounded by comparing the magnitude of the ground mode wavelet coefficients at the measurement end. Next, the impedance based method is used to identify the faulted half of the line in the case of two-terminal line and the faulted line section as well as the faulted half of the line section in the case of multi-terminal lines. Finally the fault location is determined by taking the time difference between the first two consecutive aerial modes of the current traveling waves observed at one end of the multi-terminal line. The proposed method has been tested on four- and five-terminal transmission lines with different types of faults, fault resistances and fault inception angles using ATP simulation.

1. Introduction

Location of faults in power transmission lines is one of the main concerns for all the electric utilities as the accurate fault location can help to restore the power supply in the shortest possible time. Fault location methods for transmission lines are broadly classified as impedance based method which uses the steady state fundamental components of voltage and current values [1–3], traveling wave (TW) based method which uses incident and reflected TWs observed at the measuring end(s) of the line [4,5], and knowledge based method which uses artificial neural network and/or pattern recognition techniques [6,7]. All the above methods use the measured data either from one end of the transmission line or from all ends. The method which uses the data from all ends requires synchronized measurement with time stamping and online communication of data to one central location [8–13]. On the other hand, the one-end method which does not require synchronous measurement and online communication of data is simpler to apply to multi-terminal lines.

The one-end fault location method applicable to all types of faults using TWs requires identification of the faulted half of the line in the case of two-terminal line [14], and the faulted line section as well as the faulted half of the line section in the case of multi-terminal lines. A method of identifying the faulted half of the line in the case of two-terminal line using the polarities of wavelet transform coefficients (WTCs) is reported in [10]. Another method of identifying the faulted line section and the faulted half of the line section for three-terminal line using the peak value of WTC is presented in [7]. These methods are found to be unreliable for multi-terminal lines. A method which combines the impedance based method with the TW based method to locate the fault in two-terminal line is reported in [15–17]. Here, the impedance based method is used first to find the fault location approximately and the accuracy is then improved by TW based method. As the fault location is determined approximately in this case using the impedance based method there is no need to identify the faulted half of the line. A method using the cross correlation between the forward and backward TWs to identify the fault location is proposed in [18]. It may be noted that the methods reported in [15–18] are applicable to two terminal lines only.

In this paper a fault location technique applicable to multi-terminal lines is presented. It is the extension and generalization of the method reported in [14] for two-terminal line. The developed method combines the simplicity of the impedance based method with the accuracy of the TW based method. A simplified impedance based method is used to identify the faulted line section and the faulted half of the line section. Daubechies-4 (db-4) mother wavelet is chosen for the Discrete Wavelet Transform (DWT) analysis of the current signal to obtain the time information of the incident and reflected TWs. The accurate fault location is then determined using these time information. The proposed algorithm is tested by simulating four- and five-terminal lines under different fault conditions such as various fault inception angles, fault distances and fault resistances. The constant distributed parameter line model (Clarke model) is used for simulation.

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