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Research Article

Fault Type Classification of 150 kV Transmission Line using Wavelet Multi-Resolution Analysis Method

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A B S T R A C T

To identify the fault, wavelet method is used in solving complex protection problems. This study uses a new approach, namely the wavelet multi resolution analysis method with its application where multi resolution analysis works to analyze signals at different frequencies with the same resolution. In this study, the classification of fault types that occur in the 150 kV transmission line quickly and accurately is carried out using the wavelet multi resolution analysis method. This research is included in applied research and was designed using computer simulation software, namely ATP and MATLAB. The data transmission system used is the Maninjau Hydroelectric Power Plant transmission line to Pauh Limo Substation. The modeled transmission system is given 1-phase to ground, 2-phase to ground, 2- phase, 3-phase and lightning faults. To determine the accuracy of this classification, the fault is varied according to the distance and impedance of the disturbance. From the analysis of the simulation results and calculations, based on the wavelet multi resolution analysis method used in fault classifying, the average value of the approximation coefficient used to classify the type of fault is obtained. Based on the results of the study, for phase to ground fault with fault in phase A, B and C with fault distance 45.5 km has met the classification requirements according to the multi-resolution analysis method. It can be said that for phase to ground with distance variations, the percentage of success is 100%.it can be said that all types of fault analyzed in this study have met the classification requirements using the wavelet multi resolution analysis method.

INTRODUCTION

The human population is increasing day by day. Therefore, the need for energy in daily life is also increasing. Electricity is one of the basic needs for the survival of every human being which causes the demand for electrical energy to increase. The increasing demand for electrical energy requires more generation and distribution of electricity. In general, the electric power system is divided into four parts, namely, generation, transmission, distribution and load. Of all these, the transmission and distribution system plays a major role and it is like the heart of the entire power system. However, frequent disturbances also occur in the transmission and distribution system, this will jeopardize of the overall power system security.

The transmission system consists of two types, namely overhead and underground cables. The overhead line is more widely used than the underground cable because it has several advantages. The air transmission line (overhead) will be affected by atmospheric conditions which cause the possibility of more disturbances [1]. Faults in overhead lines are classified into two types, namely open conductor faults (series) and short circuit faults (shunts). Series faults are also classified into two types, namely one-conductor open fault and two-conductor open fault.

The most common disturbance in the transmission line is short circuit (shunt) which is classified into two types, namely asymmetrical and three phase symmetrical faults, the most dangerous fault. Asymmetrical faults are phase to ground, phase to phase, and two phases to ground. The most common faults that occur in transmission line are phase to ground fault. The fault analysis can be divided into three parts, namely the faults detection, the classification of the fault and the fault location.

The analysis of fault type classification is an important part in the fault analysis [2]. There are several methods to determine the type of fault. These methods include the wavelet method [3,4,5], artificial neural networks [6,7,8], fuzzy logic [9,10,11], wavelet-neural network [12], wavelet-fuzzy [13], and neuro-fuzzy [14,15]. The kind of wavelet method is used to identification of fault types in this study, namely the wavelet multi-resolution analysis [16,17,18]. The multi-resolution analysis is a function to analyze signals at different frequencies with different resolutions [19,20,21]. In this research, fault classification is determined using multy resolution analysis. The 150 kV transmission line is used in this work. Phase to ground fault, two phase faults, three

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phase fault ant lightning fault were simulate using ATP-EMTP software and the DWT is simulated using MATLAB.

DISCRETE WAVELET TRANSFORM

Discrete wavelet transform (DWT)is considered relatively easier to implement. The basic principle of this wavelet transform is how to get a time representation of the scale of a signal using digital filtering techniques and sub-sampling operations [22]. Eq.1 is the discrete wavelet transformation general equation.

$$DWT(k,n,m) = \frac{1}{\sqrt{a_0^m}} \sum x[n]\psi\left(\frac{k-nb_0a_0^m}{a_0^m}\right) \quad (1)$$

The mother wavelet in that equation become as Eq. (2).

$$\psi_{m,n}(t) = a_0^{-m/2}(a_0^{-m}t - nb_0) \quad (2)$$

where m is the local frequency and n is the local time. In DWT, transient waves can be efficiently analyzed by multi-resolution analyzer and parsed with two filters, namely high pass filter (HPF) and low pass filter (LPF). The HPF is derived from the mother wavelet function and is measured in detail within a given input. The LPF smooths the input signal and it is derived from the scale function corresponding to the mother wavelet [23].

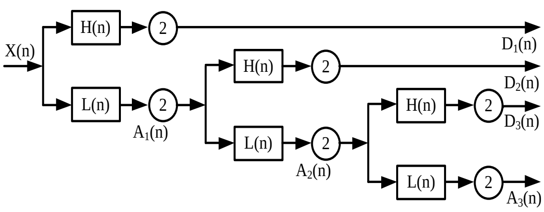

Figure 1. Signal Decoding Levels Using DWT

Based on Fig. 1, the waveform going to HPF H(n) and LPF L(n), the output of the HPF is D1 and output of LPF forwarded to the second process to be described the same as the previous process. Finally, waveform decomposition at the desired level is obtained by repeating the same process. The complete detail and approximate coefficients are obtained at level 1 (D1 and A1).
Multi-Resolution Analysis

The fault type classification algorithm can be proposed based on the wavelet energy at different levels. According to Parseval's theorem, the energy of the transient signal can be decomposed at different levels [24]. Mathematically, the wavelet energy can be expressed as Eq.3 and Eq.4.

$$E_{Di} = \sum_{j=1}^{N} |D^2 ij| \,, i = 1, \dots, l \quad (3)$$

$$E_{Ai} = \sum_{j=1}^{N} |A^2 ij| \quad (4)$$

To analyze a signal whose frequency varies with time, a transformation is needed that can provide frequency and time resolution at the same time, commonly called multi-resolution analysis (MRA) [25]. The MRA is one of the best tools for analyzing signals at different frequencies with different resolutions. MRA is designed to provide good time and poor frequency resolution at the high frequencies of a signal, as well as good frequency and poor time resolution at the low frequencies of a signal [26]. This multi-resolution analysis method is used to classify the types of disturbances that occur in the transmission line by comparing the average value of the approximation coefficient of each phase [27]. The approximation coefficient value is obtained in the decomposition processing or signal decomposition along with the detail coefficient value [28]. Mathematically, to determine the average value of the approximation coefficient is as Eq.5.

$$M_A = \frac{\sum_1^n A}{n} = M_B = \frac{\sum_1^n B}{n} = M_C = \frac{\sum_1^n C}{n} \quad (5)$$

DATA AND RESOURCES

The data used in this research is transmission line data from the Maninjau Hydroelectric Power Plant (PLTA) to Pauh Limo Substation. According to PLN UPT SUMBAR the data of this transmission line can be seen in Table.1 and the single line of transmission system can be seen in Fig.5.

Table 1. Transmission Line data

No.	Data	Specification
1	System Voltage	150 kV
2	Nominal Current	645 A
3	Lne Length	90.7 km
4	Number of Circuit	2
5	Conductor Type	HAWK
6	Conductor Cross Area	240mm^2
7	Average Power	167.58 MVA
8	Positive Sequence Impedance	R=0.117 Ω/km X=0.401 Ω/km B=2.859 μS/km
9	Negative Sequence Impedance	R=0.614 Ω/km X=1.793 Ω/km B=1.223 μS/km

The single line of transmission electrical system of West Sumatera can be seen in Fig.2.

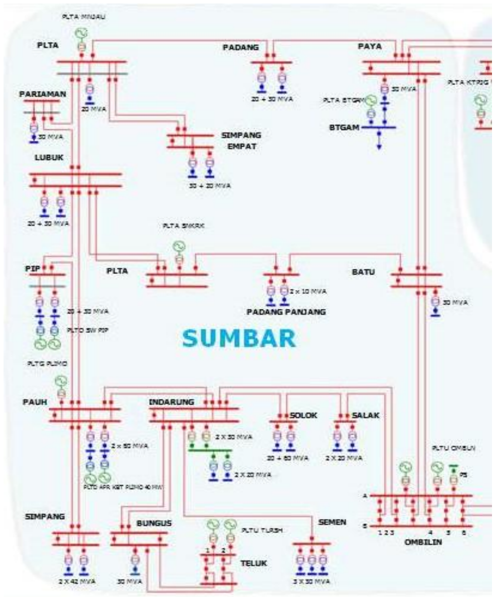

Figure 2. Single Line Diagram of the West Sumatra Electrical System

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METHOD

The method to classify the types of fault using wavelet multi-resolution analysis can be explained using flowchart. Fig. 3 explains the steps of fault classifying type using wavelet multi-resolution analysis. Fault is classified into five types of fault, They are phase to ground fault, two phase fault, two phase ground fault, three phase symmetrical fault and lightning fault [29]. All fault types are analyzed using MRA method based on approximation value comes from wavelet analysis.

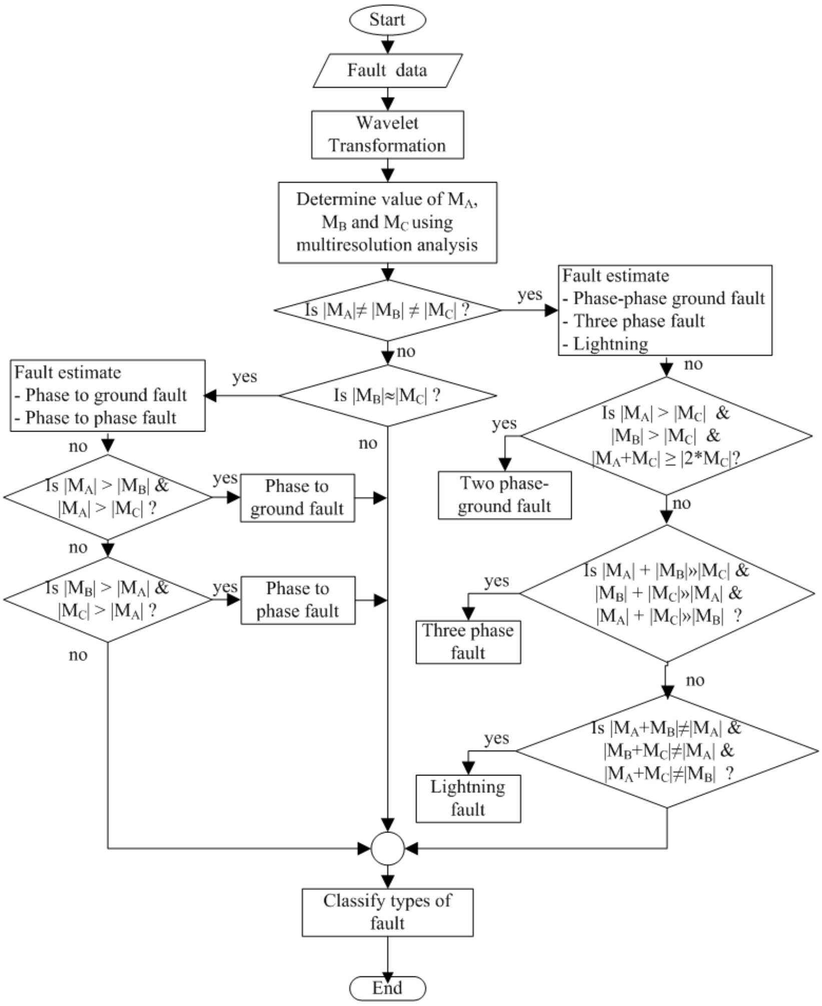

Figure 3. Flowchart of Fault Classifying Type using Wavelet Multi-Resolution Analysis

RESULTS AND DISCUSSION

The phase fault ground fault is modeled in ATP software with a distance of fault is 45.5 km from bus 1 that is Power Plant Maninjau. The bus 1 is position where the measurement point is used. The fault impedance is 1 ohm. The complete model for phase to ground fault in Sumbar transmission line can be seen in Fig. 4.

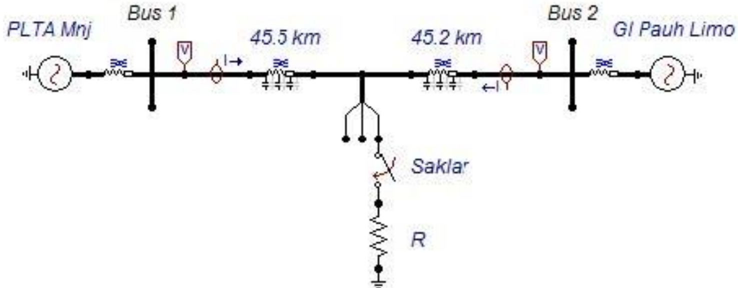

Figure 4. ATP Model of Phase to Ground Fault in Transmission Line

Table 2. Results of Fault Type in Phases AB, Phases BC and Phases AC with Various Distance

<table>
<tr><th>Fault Impedance</th><th>Fault Distance</th><th>Fault Type</th><th>MA1</th><th>MB1</th><th>MC1</th><th>MRA Criterion</th><th>Analysis</th><th>Fault Classification</th></tr>
<tr><td rowspan="3">1 Ω</td><td rowspan="9">45.5km</td><td>AG</td><td>-35810</td><td>-16894</td><td>-17041</td><td>|MA1|>|MB1|
|MA1|>|MC1|
|MB1|≈|MC1|</td><td>agree
agree
agree</td><td>Phase to ground fault</td></tr>
<tr><td>BG</td><td>9566</td><td>18734</td><td>9492</td><td>|MB1|>|MA1|
|MB1|>|MC1|
|MA1|≈|MC1|</td><td>agree
agree
agree</td><td>Phase to ground fault</td></tr>
<tr><td>CG</td><td>7402</td><td>7475</td><td>17076</td><td>|MC1|>|MA1|
|MC1|>|MB1|
|MA1|≈|MB1|</td><td>agree
agree
agree</td><td>Phase to ground fault</td></tr>
<tr><td rowspan="3">10 Ω</td><td>AG</td><td>-28367</td><td>-13479</td><td>-13627</td><td>|MA1|>|MB1|
|MA1|>|MC1|
|MB1|≈|MC1|</td><td>agree
agree
agree</td><td>Phase to ground fault</td></tr>
<tr><td>BG</td><td>6361</td><td>11930</td><td>6287</td><td>|MB1|>|MA1|
|MB1|>|MC1|
|MA1|≈|MC1|</td><td>agree
agree
agree</td><td>Phase to ground fault</td></tr>
<tr><td>CG</td><td>7192</td><td>7266</td><td>16437</td><td>|MC1|>|MA1|
|MC1|>|MB1|
|MA1|≈|MB1|</td><td>agree
agree
agree</td><td>Phase to ground fault</td></tr>
<tr><td rowspan="3">20 Ω</td><td>AG</td><td>-22484</td><td>-10762</td><td>-10910</td><td>|MA1|>|MB1|
|MA1|>|MC1|
|MB1|≈|MC1|</td><td>agree
agree
agree</td><td>Phase to ground fault</td></tr>
<tr><td>BG</td><td>4124</td><td>7290</td><td>4050</td><td>|MB1|>|MA1|
|MB1|>|MC1|
|MA1|≈|MC1|</td><td>agree
agree
agree</td><td>Phase to ground fault</td></tr>
<tr><td>CG</td><td>6712</td><td>6786</td><td>15195</td><td>|MC1|>|MA1|
|MC1|>|MB1|
|MA1|≈|MB1|</td><td>agree
agree
agree</td><td>Phase to ground fault</td></tr>
</table>

Table 2 shows that the classification results for 1-phase ground faults with faults in phases A, B and C for fault distance 45.5 km meet the classification requirements according to the multi-resolution analysis method. From the results of this classification, it can be said that for phase to ground with distance variations, the percentage of success is 100%.

CONCLUSIONS

All model components that is used in the simulation of this study have been successfully build and work well according to research needs. From the analysis of the simulation results and calculations, based on the wavelet multi-resolution analysis method is used in classifying the type of faults, the average value of the approximation coefficient is obtained. This approximation coefficient is used as parameter by MRA to classify the type fault. All types of faults which is analyzed in this study met the classification requirements using the MRA method. In other words, the simulation of the classification of the type of fault met 100% successfuly.

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