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Application of Wavelet Technique for Fault Classification in Transmission Systems

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Abstract

Transmission systems (TS) plays a major role in electrical power systems. The interruption caused to the consumer because of TS faults is substantial. So TS needs a proper protection scheme to ensure continuous power supply to the consumers. This study proposes a novel scheme using wavelet technique for classification of faults in TS. In order to do so, the proposed scheme uses current measurements of just one side of the transmission line. Simulations are performed under different fault conditions using MATLAB. The stability of the proposed scheme under various cases is tested andreliable results have been obtained.

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*Keywords:*Fault; Fault classification; Transmission systems; Transmission line protection; Wavelet technique; Multi resolution analysis

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1. Introduction

Here in this world, major number of problems are linked with population. The population on the earth increasing day by day. Due to this the requirement of energy in daily life gradually increasing. Electricity is the one of the basic need for survival to everyone on this earth. And hence the demand for electricity is raising, which means there is a necessity for more power generation. It is a challenging task for power engineers to provide good quality and un-interrupted power to the consumers. Generally the power system is divided into four parts namely, generation, transmission, distribution and utilization. Out of all these transmission plays major role and it is like a heart of the entire power system. But in entire power system maximum number of faults occurs in transmission systems. Transmission can be done in two ways,one is over head and other is underground. The predominant way to transmit the power is by using over headlines due to its inherent advantages over underground cables. Overhead transmission lines (OHTL) are exposed to atmospheric conditions because of this the possibilities of fault occurrence in OHTL is more [1]. Henceforth the main objective of power engineers is to implement a better protection scheme to TS.

Faults in OHTL are mainly classified into two types, one is open conductor (series) and short circuit (shunt) faults. Series faults are again classified into two types, one is one open conductor faults and other is two open conductor fault. Compared to shunt faults, open conductor faults very rarely occur. The most commonly occurring faults in transmission lines are short circuit faults. Short circuit faults are classified into two types, symmetrical faults and unsymmetrical faults. Symmetrical faults are 3-phase faults, these are most sever faults. Unsymmetrical faults are line to ground, line to line and double line to ground faults. The most frequently occurring fault in TS is line to ground fault. Fault analysis can be divided into three parts namely, fault detection, fault classification and fault location. Fault classification is one of the major task in fault analysis [2].There are a couple of techniques that can be employed in simulation for this purpose. The major techniques are wavelet technique [3], [9], [12], artificial neural networks [5], [11], [14], fuzzy logic [4], [13], [15], wavelet-neural networks [8], wavelet-fuzzy [10], neuro-fuzzy [6], [7]. The accuracy and time response of wavelet approach is better than all the other major techniques and it provides much better results. In order to identify the nature of faults, wavelet techniques are extensively used to solve complex protection issues. This article presents a novel approach using application of wavelet technique for fault classification using one of the terminal end currents of the TS.

This paper is prepared as follows. Section 2 gives introduction to wavelets. Section 3,explains the classification of faults using wavelet technique. Section 4,explains the outcomes of the presented technique. Lastly, Section 5 givesthe conclusion.

2. Wavelet Technique

Wavelet technique is a powerful mathematical tool, useful for processing signals.Wavelet technique appropriately chooses a proper wavelet function known as mother wavelet and this selected function is analysedusing translated and scaled versions.It can analyse the transient, non-stationary or time varying phenomena. Multi resolution analysis (MRA) is one of the best tools to analyse the signals at different frequencies with different resolutions.MRAis designed to give poor time resolutionand good frequency resolution at low frequencies, poor frequency resolution and good time resolution at high frequencies. This approach mainly useful for low frequency component signals for long durations and high frequency component signals for short durations. Another best application of wavelet technique is multi-level decomposition. Signal can be decomposed until individual details contains a single sample by using multi-level decomposition.

Wavelet technique has been in operation in lot of different areas and provides an added advantage of low time response, which improves system efficiency. It has the ability of performing local analysis to the best level without hampering lot of time frequency data. Hence wavelet technique will be very useful in the power system fault analysis and so this articlepresents a novel approach using wavelet technique to identify nature of faults.

3. Fault classification using wavelet technique

The power system model considered for the simulation is as shown in single line diagram inFig. 1. A three phase transmission line of 200-km, operating with 400-kV sources at a load angle of 20^0 has been for simulation of proposed technique. The three phase currents are indicated as A, B and C respectively. And the ground is represented as G.

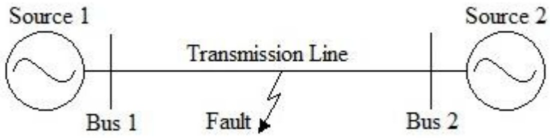

Fig. 1. Power system model

The below figures (Fig. 2. (a)-(i)) shows the simulation outputs of phase currents for different faults under various operating conditions.

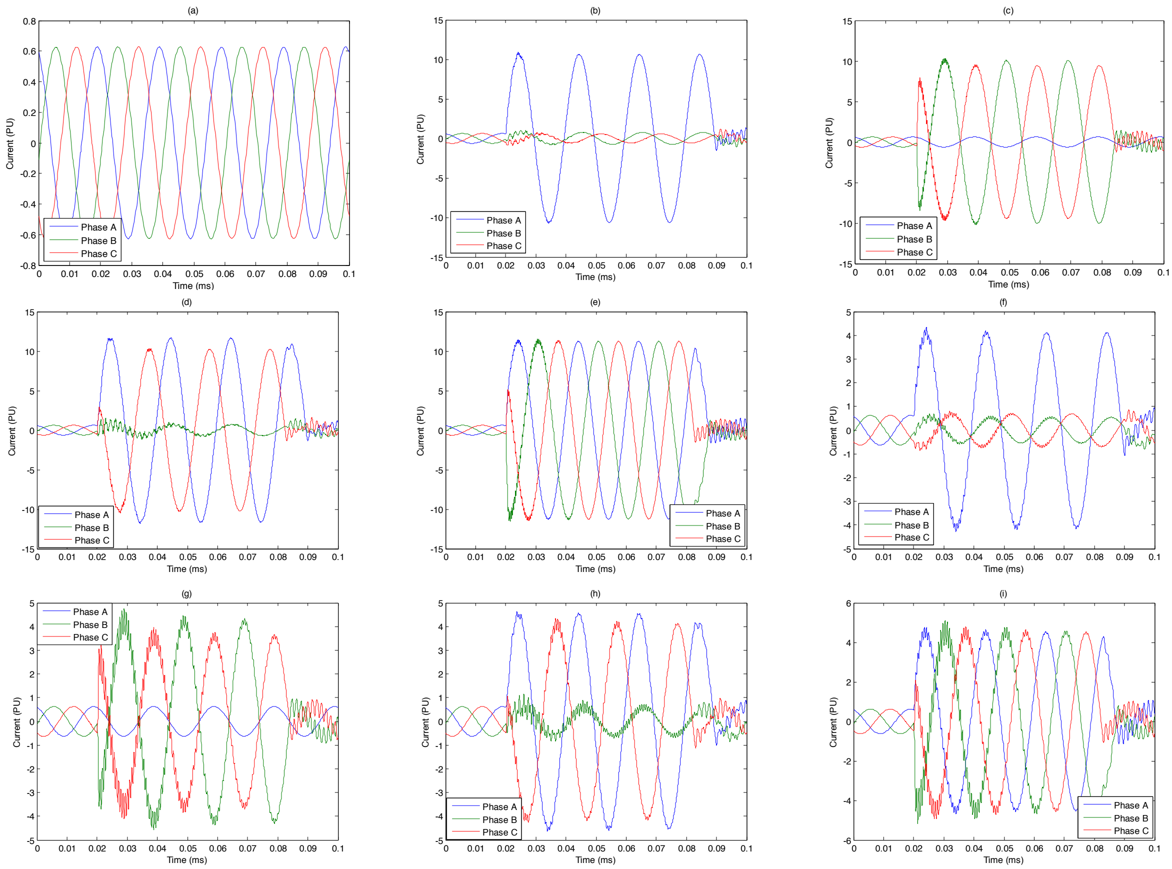

Fig. 2. (a) Phase currents for Healthy system. (b)-(e) Phase currents at 50km, R_f=100 Ω for AG, BC, CAG and ABC faults respectively. (f)-(i) Phase currents at 150km, R_f=100 Ω for AG, BC, CAG and ABC faults respectively.

In this work, the application of wavelet technique is applied to fault detection and classification is done using one terminal end currents only. This approach uses discrete wavelet transform (DWT) with MRA. All three phase currents are decomposed to approximations (A) and details (D) by using db1 wavelet. The abnormal condition in each phase current can be found out by using details (D1) of the first decomposition level. The norm of detail coefficients can be calculated by using the following equation,

$$\|D1\| = \left[\sum_{k=1}^{n_d} |D1(k)|\right]^{1/2} \tag{1}$$

Where n_d indicates number of the detail coefficients at a certain level.
If the calculated norm value is more than threshold value, then that phase is called faulty phase. If all three phasecurrent norm values are less than thresholds, transmission system is in healthy condition.

4. Results

The below figures (Fig. 3 - Fig.14) shows the norm of D1 coefficients for different type of faults. The threshold value for the selected system is 0.25.

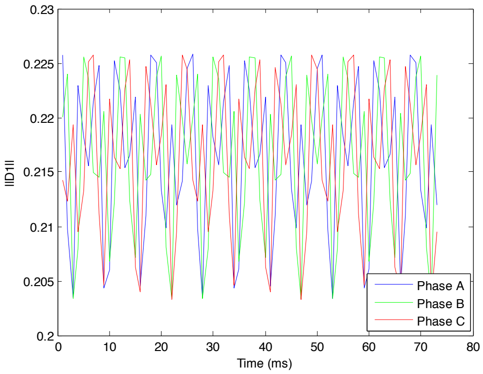

Fig. 3. Norm of D1 coefficients for Healthy System

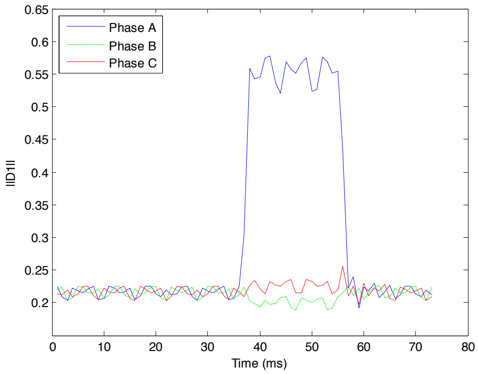

Fig. 4. Norm of D1 coefficients for AG fault

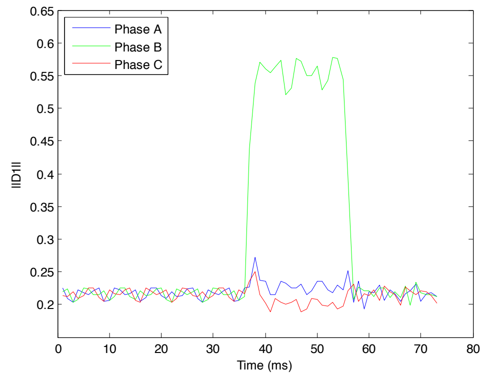

Fig. 5. Norm of D1 coefficients for BG fault

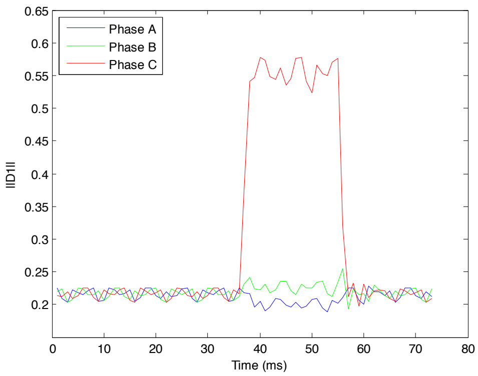

Fig. 6. Norm of D1 coefficients for CG fault

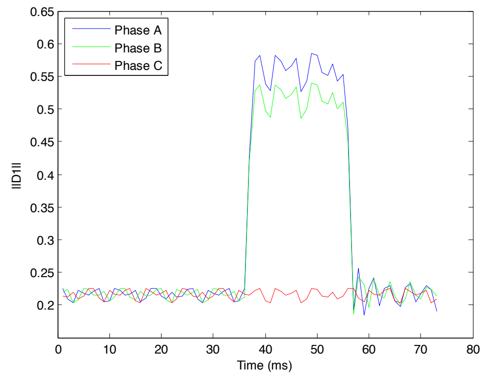

Fig. 7. Norm of D1 coefficients for AB fault

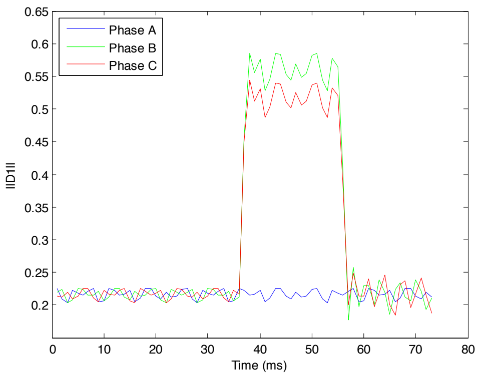

Fig. 8. Norm of D1 coefficients for BC fault

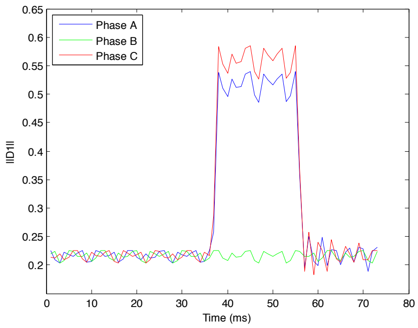

Fig. 9. Norm of D1 coefficients for CA fault

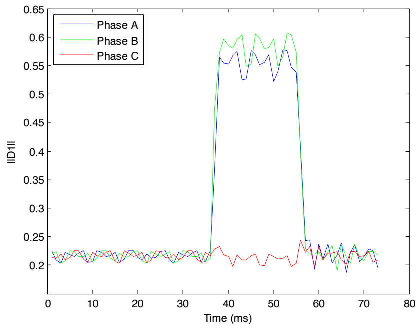

Fig. 10. Norm of D1 coefficients for ABG fault

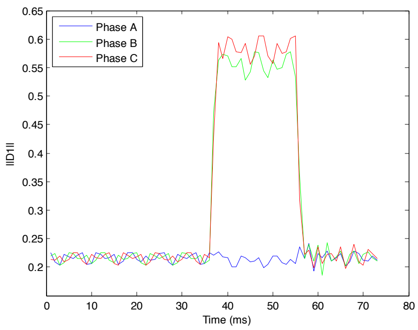

Fig. 11. Norm of D1 coefficients for BCG fault

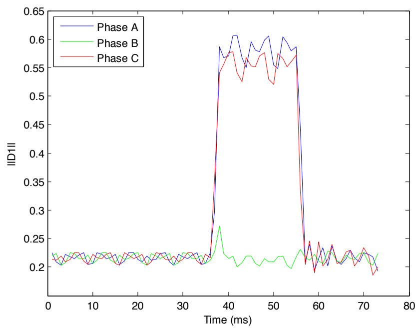

Fig. 12. Norm of D1 coefficients for CAG fault

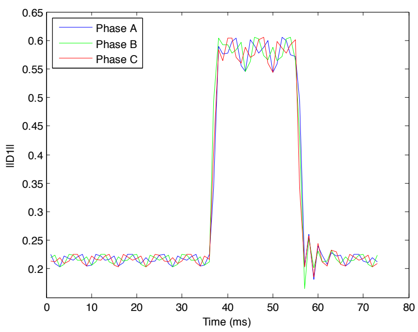

Fig. 13. Norm of D1 coefficients for ABC fault

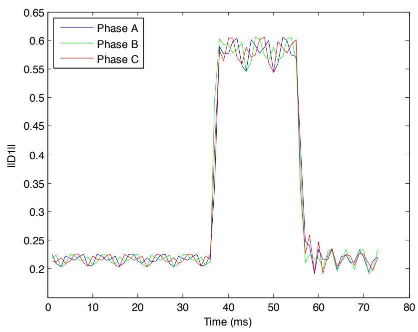

Fig. 14. Norm of D1 coefficients for ABCG fault

Table 1. A summary of fault classification at a loadangleof20^{0}and R_f=100 Ω

S. No.	Applied Fault Type	Description	Discovered Fault Type	Figure No.
1	Healthy	Norm values of all three phase currents less than threshold value	Healthy	3
2	AG	Norm value of Phase A current exceeds threshold value	AG	4
3	BG	Norm value of Phase B current exceeds threshold value	BG	5
4	CG	Norm value of Phase C current exceeds threshold value	CG	6
5	AB	Norm values of Phase A and Phase B currents exceeds threshold value	AB	7
6	BC	Norm values of Phase B and Phase C currents exceeds threshold	BC	8

value

S. No.	Applied Fault Type	Description	Discovered Fault Type	Figure No.
7	CA	Norm values of Phase C and Phase A currents exceeds threshold value	CA	9
8	ABG	Norm values of Phase A and Phase B currents exceeds threshold value	ABG	10
9	BCG	Norm values of Phase B and Phase C currents exceeds threshold value	BCG	11
10	CAG	Norm values of Phase C and Phase A currents exceeds threshold value	CAG	12
11	ABC	Norm values of all three phase currents exceeds threshold value	ABC	13
12	ABCG	Norm values of all three phase currents exceedsthreshold value	ABCG	14

5. Conclusion

The application of wavelet technique for classification of faults in overhead transmission lines has been presented in this article. The DWT collaborated with MRA was used to overcome the disadvantages of earlier techniques.DWT is used to decompose current signals into different frequency bands using MRA and based on it the nature of fault is identified. The nature of faults is classified accurately by using details (D1) at the first decomposition level of currents. If the calculated norm value of details in any phase exceeds the threshold value, it indicates that particular phase is under fault condition, if not it indicates that phase is in healthy condition. The simulations have been carried out under different varying conditions using MATLAB/Simulink. The presented approach gives correct results for any type of fault and this approach can be used apply for high fault resistances up to 500 Ω.

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