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DETECTION OF FAULTS IN OVERHEAD LINES USING DISCRETE WAVELET TRANSFORM

Avagaddi Prasad[1] and J. Belwin Edward[2]

[1]Department of Electrical and Electronics Engineering, Sree Vidyanikethan Engineering College, Tirupathi, A.P, India. [2]School of Electrical Engineering, VIT University, Vellore, Tamil Nadu, India

ABSTRACT

Fault detection is a primary concern in isolation of faults. The present protective relaying systems used for fault detection are not precisely functioning which may lead to entire system shut down. The necessity to improve performance of present protective schemes used in power systems is rapidly increasing due to the drastic changes in power system working environment. This work shows a strategy for fault detection in overhead systems using discrete wavelet transform by overcoming the problems faced in conventional methods. This strategy utilizes just fault current estimations toward one side of the overhead line to detect the faults. The sufficiency of proposed technique is analyzed under a different fault conditions using technical computing tool. The results obtained are encouraging and also it is found out that the accuracy in proposed fault detection methodology has increased considerably.

Index Terms— Fault, fault detection, discrete wavelet transform, overhead lines, protection.

I. INTRODUCTION

Power transmission system is significant fragment in whole power system and also maximum percentage of faults occurs in transmission system. Generally, the power transmitted from generation side to distribution side through overhead lines. Overhead lines are exposed in atmospheric nature, so the chances for occurring faults are more. Based on nature of fault the losses in system depends, i.e. losses depend on severity of fault. If the occurred fault is phase to ground, then it is less severing and if the occurred fault is three phase faults then it means more sever. To avoid the major damages, protective systems introduced in power system. Firstly, the power system divided into different zones for each zone different protection schemes employed (Ross and Bell 1930, Girgis and Johns 1989, Youssef 2001 and 2004a). In transmission system zone protective relaying systems are used for fast identification of faults. Each method has their own limitations, so the need of improvisation in performance wise in existing schemes is necessary.

A few strategies have been anticipated to accomplish correct outcomes (Mahanty and Gupta 2004). The primary point of these methods is to register impedance at the principal recurrence. As per the figured impedance, the fault is distinguished as outer or inside to the protection zone. This impedance is ascertained from the deliberate current and voltage signals at the transfer area. Notwithstanding the crucial frequency, the signs regularly contain dc component and harmonics, which aggravate the precision of the phasor estimation (Wang and Keerthipala 1989, Vasilic and Kezunovic 2005).

As of late, distance relays have encountered much advancement because of the reception of computerized relaying. Signal processing is one the very pinnacle of huge bit for strategy of the computerized distance protection (silva et al., 2006, Prasad and Edward 2016, Youssef 2004b). As of not long ago, kalman filtering and fourier methodologies were the main tools for distance relaying (Seyedtabaii 2012). The trip/no trip result have been enhanced, contrasted with the electromechanical relays. In any case, the achieve precision of these procedures is influenced by the diverse fault conditions for the most part in the presence of dc offset and high frequency in the signals (Perez et al., 2011, Samantaray 2013, He et al., 2014).

The significance of soft computing techniques is increasing in every industry due to their tremendous outcomes (Parsad 2015). Part of research is going ahead around there to execute superior procedures contrasted with more established ones (Dalstein and Kulicke 1995, Ferrero et al., 1995, Kumar et al., 1999). In power sector side also, soft computing techniques are using for minimization of losses and in protective schemes, etc. The most used soft computing techniques for fault analysis in overhead lines are wavelet technique (Das and Reddy 2005, Amna 2017), artificial neural networks (Razi 2007, Parsad 2016a) and fuzzy logic (Parsad 2016b, Reddy and Mohanta 2007). A hybrid method is a combination of two or more techniques, which means it's a summation of advanced features of each technique and elimination of drawbacks of each method. Some hybrid methods named as wavelet-neural networks (Jung et al., 2007), wavelet-fuzzy (Christy et al., 2017), neuro-fuzzy (Cecati and Razi 2012) and wavelet neuro fuzzy (Mahanty and Gupta 2007) also used for fault analysis. The precision of wavelet approach is superior to all the other main techniques and it provides much improved results. This article exhibits a novel technique for blame identification utilizing just post fault current specimens toward one side of the overhead line with the assistance of discrete wavelet change (DWT).

This article is prepared as follows. Introduction to DWT presented in Section 2. The proposed fault detection algorithm using DWT explained in Section 3. Finally, Section 4 gives the conclusion.

II. DISCRETE WAVELET TRANSFORM

Wavelets are an as of late settled scientific apparatus for signal processing. Contrasted with fourier methodologies, which depends on a single basis function, various premise elements of a somewhat wide useful shape are accessible in wavelet investigation. The essential hypothesis in wavelet transform (WT) is to choose an appropriate wavelet function as mother wavelet and after that execute investigation utilizing enlarged and moved adaptations of this wavelet. Wavelet can be chosen with vital time and frequency qualities when contrasted with fourier methodologies.

WT with the help of multi resolution analysis (MRA) can break down signals into various frequency bands. These are useful in recognizing deficiencies, which are required for fault analysis. The continuous wavelet transform (CWT) was created as an option way to deal with STFT to beat the resolution issue.

CWT is characterized as follows:

$$CWT_X(a,b) = \frac{1}{\sqrt{|a|}} \int X(t)\Psi\left(\frac{t-b}{a}\right)dt \qquad (1)$$

Where x(t) is a signal or a function x(t),

a is dilation,

b is translation,

ψ is mother wavelet,

$\frac{1}{\sqrt{|a|}}$ is for energy normalization across different scales

In DWT, the translation and scale factors are discretized, yet not the autonomous variable of the first signal. It is to be noticed that the two variables a and b are continuous in continuous transformation. Be that as it may, in the reconstruction procedure, the reconstruction will be separated in little portions for ease of computer execution. A DWT brings about a limited number of wavelet coefficients relying on the whole number of the discretization step in scale and translation, showed by m and n.

$$DWT_X(m,n) = \frac{1}{\sqrt{a_0^m}} \sum_l X(k)\Psi\left(\frac{n-la_0^m}{a_0^m}\right)dt \qquad (2)$$

Compared to CWT, DWT conveys suitable data for both synthesis and analysis in less time. So, DWT is significantly less demanding to execute when contrasted with CWT.

III. Fault Detection

Fault analysis can be divided into 3 parts. So fault detection is first stage in fault analysis, if in this stage protective scheme fails to detect the fault means, there is a chance to shut down entire system. Hence fault detetion is essential task in fault analysis. The considered simulation model appeared in Fig. 1.

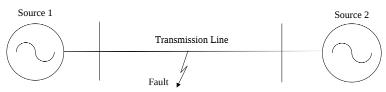

Fig. 1. System under study

A. Fault Detection using DWT

Daubechies wavelet used as a mother wavelet, to calculate the details of each phase current signals. By computing the norm, the fault detection can be achieved. The proposed fault detection algorithm is depicted in Fig. 2.

$$S = P + Q + R \qquad (3)$$

If S > th, fault occurred

S < th, fault not occurred. (4)

Where P, Q, R is the maximum value of norm of the detail coefficients for phase A. phase B and phase C respectively. Threshold value indicates with th. S is sum of P, Q and R.

If the sum (S) of maximum value of norm of the detail coefficients for each phase (P, Q and R) is exceeds the threshold value (th) means fault occurred, if sum (S) is less than threshold value (th) means fault not occurred. Transmission line models are generally classified into 3 types based on their length. They are short, medium and long transmission line. The proposed technique tested for all three transmission lines. The tabulations of fault detection algorithm for each transmission model mentioned below.

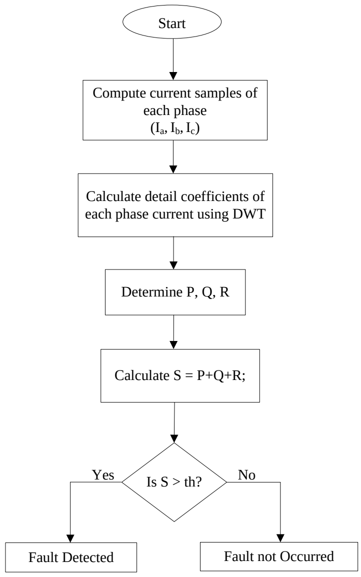

Fig. 2. Flowchart for fault detection algorithm

i. For short transmission line model

The overhead lines which have length under 80 km are for the most part alluded as short transmission lines. A 20kV source voltage, load angle of 20^0, fault resistance of 100 Ω for 3 phase systems with 75 km line is considered to simulate the proposed technique. The threshold value (th) for this configuration is 0.1. The validation for fault detection algorithm for short transmission line model is tabulated in following Table I.

TABLE I: Justification of proposed strategy short transmission line model

S. No.	Nature of Fault	P	Q	R	S	S > th (Yes or No)	is fault detected ? (Yes or No)
1	Healthy Condition	0.0308	0.0308	0.0308	0.0924	No	No
2	Line to Ground	0.1813	0.0367	0.0361	0.2541	Yes	Yes
3	Line to Line	0.1695	0.0308	0.1723	0.3726	Yes	Yes
4	Double line to Ground	0.0570	0.1789	0.1857	0.4216	Yes	Yes
5	Triple Line	0.1836	0.1835	0.1836	0.5507	Yes	Yes
6	Triple line to Ground	0.1836	0.1835	0.1836	0.5507	Yes	Yes

ii. For medium transmission line model

The overhead line having its length more than 80 km yet under 250 km, is for the most part alluded to as a medium transmission line. The validation for fault detection algorithm for medium transmission line model is tabulated in following Table II.

TABLE II: justification of proposed strategy for medium transmission line model

S. No.	Nature of Fault	P	Q	R	S	S > th (Yes or No)	is fault detected ? (Yes or No)
1	Healthy Condition	0.1009	0.1008	0.1009	0.3026	No	No

2	Line to Ground	0.3859	0.1191	0.1223	0.6273	Yes	Yes
3	Line to Line	0.3648	0.1008	0.3785	0.8441	Yes	Yes
4	Double line to Ground	0.1763	0.3803	0.4051	0.9617	Yes	Yes
5	Triple Line	0.3995	0.3993	0.3994	1.1982	Yes	Yes
6	Triple line to Ground	0.3995	0.3993	0.3994	1.1982	Yes	Yes

iii. For long transmission line model

The overhead lines which have length around 250 km or above is alluded as a long transmission line. A 400kV source voltage, load angle of 20^0, fault resistance of 100 Ω for 3 phase systems with 500km line is considered to simulate the proposed strategy. The validation for fault detection algorithm for long transmission line model is tabulated in following Table III.

Table III: Justification of proposed strategy for long transmission line model

S. No.	Nature of Fault	P	Q	R	S	S > th (Yes or No)	is fault detected ? (Yes or No)
1	Healthy Condition	0.3614	0.3615	0.3616	1.0845	No	No
2	Line to Ground	0.6735	0.4047	0.4407	1.5189	Yes	Yes
3	Line to Line	0.6750	0.3615	0.7639	1.8004	Yes	Yes
4	Double line to Ground	0.4059	0.7204	0.7631	1.8894	Yes	Yes
5	Triple Line	0.7743	0.7739	0.7744	2.3226	Yes	Yes
6	Triple line to Ground	0.7743	0.7739	0.7744	2.3226	Yes	Yes

IV. Conclusion

A DWT based fault detection scheme is introduced in this article. It utilizes post fault current samples of all phases to determine the detail coefficients of each phase by using duchies wavelet as mother wavelet. Whenever there is a fault in the transmission system, the sum (S) of maximum value of norm of the detail coefficients of each phase (P, Q and R) exceeds the threshold value (th) and during healthy conditions the sum (S) will be lesser than the threshold value (th). The robustness of the proposed strategy has been tried on different types of transmission line models (short, medium and long) under different fault conditions utilizing MATLAB. The outcomes demonstrates that presented fault detection technique is suitable for any type of transmission line model.

References

Amna M. Ali, Activity of thuja (thuja orientalis) alcoholic extract in inhibition aspergillus flavus growth and detoxification of aflatoxin B1 in contaminated corn seeds. Pak. J. Biotechnol. 14(3): 503-506 (2017)

Cecati C. and K. Razi, Fuzzy-logic-based high accurate fault classification of single and double-circuit power transmission lines, P*roceedings of international symposium on power electronics, electrical drives, automation and motion*, Sorrento, Pp. 883-889 (2012).

Christy, A., Jeba M. and G. Kousalya, calibration free fingerprint-based support vector regression for indoor position system. Pak. J. Biotechnol. 14(3): 497-502 (2017)

Dalstein T. and B. Kulicke, Neural network approach to fault classification for high speed protective relaying. *IEEE Transactions, Power Delivery* 10 (2): 1002-1011 (1995).

Das B. and V.J. Reddy, Fuzzy-logic-based fault classification scheme for digital distance protection. *IE EE Transactions, Power Delivery* 20(2); 609-616 (2005).

Ferrero A., Sangiovanni S. and E. Zappitelli, A fuzzy-set approach to fault- type identification in digital relaying. *IEEE Transactions, Power Delivery* 10 (1); 169-175 (1995).

Girgis A, and M.B. Johns, A hybrid expert system for faulted section identification, fault type classifcation and selection of fault location algorithms. *IEEE Transactions, Power Delivery* 4(2):978-985 (1989).

He Z., Lin S., Deng Y., Li X. and Q. Qian, A rough membership neural network approach for fault classification in transmission lines. *Electrical Power & Energy Systems* 61: 429-439 (2014).

Jung C.K., Kim K.H., Lee J.B. and B. Klockl, Wavelet and neuro-fuzzy based fault location for combined transmission systems. *Electrical Power and Energy Systems* 29(6); 445–454 (2007).

Kumar P., Jarni M., Thomas M.S. and Moinuddin, Fuzzy approach to fault classification for transmission line protection, *in proceedings of the IEEE region 10^th^ conference*, Cheju Island, 15-17: 1046-1050 (1999).

Mahanty R.N and D.P.B. Gupta, A fuzzy logic-based fault classification approach using current samples only. *Electric Power Systems Research*, 77(5-6): 501–507 (2007).

Mahanty R.N. and P.D. Gupta, Application of RBF neural network to fault classification and location in transmission lines, *proceedings of Generation, Transmission and Distribution* 151(2): 201-212 (2004).

neering Conference International, Singapore Pp. 42-46 (2007).

Pérez F.E., Orduna E. and G. Guidi, Adaptive wavelets applied to fault classification on transmission lines. *Generation, Transmission & Distribution IET* 5 (7): 694-702 (2011).

Prasad A. and J.B. Edward, Application of Wave-let Technique for Fault Classification in Transmission Systems. *Procedia Computer Science* 92: 78-83 (2016).

Prasad A., Edward J.B. and K. Ravi, A Review on Fault Classification Methodologies in Power Transmission Systems, Part−I. *Journal of Electrical Systems and Information Technology* (2016a) https://doi.org/10.1016/j.jesit.2017.01.004.

Prasad A., Edward J.B. and K. Ravi, A Review on Fault Classification Methodologies in Power Transmission Systems: Part−II. *Journal of Electrical Systems and Information Technology* (2016b) http://dx.doi.org/10.1016/j.jesit.2016.10.003.

Prasad A., Edward J.B., Roy C.S., Divyansh G. and A. Kumar, Classification of Faults in Power Transmission Lines using Fuzzy Logic Technique. *Indian Journal of Science and Technology* 8(30): 1-6 (2015).

Razi K., Hagh T.M. and G.H. Ahrabian, High acc-urate fault classification of power transmission lines using fuzzy logic, P*roceedings of Power Engi-*

Reddy J.M. and D.K. Mohanta, A wavelet fuzzy comb-ined approach for classification and location of transmission line faults. *Electrical Power and Energy Systems* 29(9); 669–678 (2007).

Ross T.W. and H.G. Bell, Recent developments in the protection of three-phase transmission lines and feeders. *Electrical Engineers. Journal of the Institution* 68(403): 801-823 (1930).

Samantaray S.R., A systematic fuzzy rule based appro-ach for fault classification in transmission lines. *Applied Soft Computing* 13(2): 928-938 (2013).

Seyedtabaii S. Improvement in the performance of neural network-based power transmission line fault classifiers. *IET generation, transmission & distribution* 6(8): 731-737 (2012).

Silva K.M., Souza B.A. and N.S. Brito, Fault dete-ction and classification in transmission lines based on wavelet transform and ANN. *IEEE Trans-actions, Power Delivery* 21(4): 2058-2063 (2006).

Vasilic S. and M. Kezunovic, Fuzzy ART neural network algorithm for classifying the power sys-tem faults. *IEEE Transactions, Power Delivery* 20(2): 306-1314 (2005).

Wang H. and W.W. Keerthipala, Fuzzy-neuro approach to fault classification for transmission line protection. *IEEE Transactions, Power Deli-very* 13(4): 1093-1104 (1989).

Youssef O.A., A novel fuzzy-logic-based phase selection technique for power system relaying. *Electric Power Systems Research* 68(3): 175-184 (2004a).

Youssef O.A., Combined fuzzy-logic wavelet based fault classification technique for power system relaying. *IEEE Transactions, Power Delivery.* 19(2): 582-589 (2004b).

Youssef O.A., Fault classification based on wavelet transforms, *in proceedings of Transmission and Distribution Conference and Exposition* IEEE/ PES 1: 531-536 (2001).