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Fault Detection and Classification in Power Transmission Lines Based on Transient Signal Analysis: A Review of Different Methodologies

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Abstract

Transmission lines are integral part of the power system. Majority of faults occurring in these power systems are due to faults in the transmission lines. The fault detection and its classification is a challenging task in order to improve overall reliability of the system. This paper presents an exhaustive literature survey for comparative study of different methods used for fault detection and analysis based on wavelet transform.

1. Introduction

The occurrence of faults in a transmission line is uncertain. There are various reasons of fault. A contact between two or more lines causing short circuit or one or more lines coming in contact with ground in three Phase systems are some of the reasons [1]. Lightning ionizing the air, flashovers, birds striking the transmission lines, deformation of insulators leading short circuits, are also responsible [2].Whatever may be the reason, once a fault occurs, the protection relays of the system gets tripped resulting system breakdown . A fault has to be identified and classified before the tripping of relays, so as to understand the reason for breakdown. Thus fault detection and classification becomes a very vital task. Many methods are proposed for determination of faults and their classification in three phase transmission lines. Conventional methods used fuzzy logics [3] and ANN (Advanced Neural Networks) [4] for this purpose. The main drawback of neural networks methods is that for good performance, it requires a considerable amount of training effort. This condition becomes critical under a wide variation of operating conditions such as system loading level, fault resistance, source impedance, etc. Also in neural networks, the training may not converge in some cases, due to random selection of starting point [5]-[6].Thus we need another better method and that is where wavelet transforms come into play. When compared to the results obtained by using ANN, it was found that wavelet transform proves far better.

Continuous wavelet transforms (CWT) and discrete wavelet transforms (DWT) are two broad categories of wavelet transforms based on which many novel methods are proposed by different researchers. The transients occurring due to fault can be analyzed by using both these wavelet transform types. The challenging task is analysis of these transients. The most prominent faults occurring in transmission lines are of four types. 1) Single phase to ground fault(L-G) 2) Line to line fault(L-L) 3) Double line to ground fault(D-L-G) 4) Three phase short circuit fault(L-L-L). Where we name the three phases as A, B, C respectively and ground as G. These faults are further classified by making subsequent sets, into total eleven faults. [7]

In this paper we compare various methods of fault detection and classifications by using wavelet transforms. Some methods use continuous wavelet transforms (CWT) [8] while there are many methods which use discrete wavelet transforms (DWT) [1-2][9-10].Some methods use the combination of ANN(advanced neural networks) and discrete wavelet transforms [11]. We do a comparative analysis of these methods on the basis of faults type to give a conclusion about the best type of wavelet transform for fault detection and classification.

2. Wavelet Transform Approach for Different Kinds of Faults

The frequency analysis range at which Wavelet Transform can offer a better compromise in terms of localization governs the size of analysis window. This becomes main advantage of Wavelet Transform [12]. The Wavelet Transform is feasible and practical for analyzing power system transients and disturbances. We simulate each fault condition by using different simulators like PSCAD/EMTDC [13], ATP/EMTP [14], MATLAB/SIMULINK [1] and SVM [15] which is followed by rigorous transform analysis of these transient signals which we get due to the occurrence of this fault. We then summarize our results for each type of fault.

2.1 Single phase to ground Fault (L-G)

Line to ground fault can occur between any lines or phase either A, B or C and ground. Thus these faults are of types A-G fault, B-G fault, C-G fault [7]. In algorithm with CWT approach [8], simulation of the fault case (L-G) is done using MATLAB; the transient signals so obtained are analyzed by using both mother wavelets Mexican hat and Coif Let respectively. In both the cases it is observed that as the distance at which the fault had occurred increases, the percentage of error increases along with that but it can be clearly seen that the percentage of error in case of Mexican hat wavelet method is very less as compared to that of the Coef-let method [8].

We also analyze this fault by the use of DWT. We find that the results obtained in [2] clearly indicate that DWT computation followed by energy estimation of transients is not a much reliable method for particularly B-G fault. The best method for this purpose is the one with DWT computation and use of SVM [9].

2.2 Line to line Fault (L-L)

Line to line fault is a kind of fault that can occur in between any two phases thus it can be of types A-B fault, B-C fault, A-C fault [7]. As same as in the case of L-G fault, for algorithm using CWT we select the simulation case corresponding to phase to phase fault. We can take fault between any two phases. The results are then studied. Unlike the L-G fault case, here we find that, as the distance at which fault occurs increases the percentage of error decreases in both the cases. It can be clearly seen that the percentage error in case of Mexican hat wavelet transform is low as compared to that of the coif let method. Hence Mexican hat method is more useful in case of L-L fault [8].

In DWT approach, we analyze this fault by using different algorithms [1]-[2] [9]-[10]. In all of them transient analysis is done by using DWT. We find that out of various algorithms used, the method of data reduction described in [1] appears to be best suitable for this kind of fault detection and classification.

2.3Double Line to ground Fault (DL-G)

These faults cannot be detected and classified by using CWT. For these types of faults detection we have to rely only on methods using DWT. We also find that as indicated in [10] DWT analysis along with energy estimation is not very accurate method for this kind of fault. The method with DWT and SVM analysis as indicated in [9] is the most accurate method out of all available methods for such kind of fault analysis.

2.4 Three phase Fault (L-L-L)

Similar to above two cases of L-G and L-L, for L-L-L fault we select the simulation case with phase-'A' to phase -'B' to phase -'C' fault. The results are compared. In CWT approach, unlike the L-G fault case, here we find that, as the distance at which fault occurs increases the percentage of error decreases in both the cases. It can be clearly seen that the percentage error in case of Mexican hat wavelet transform is low as compared to that of the coif let method. Hence Mexican hat method is more useful in case of L-L-L FAULT [8].

When we simulate this fault using DWT analysis, we find all the proposed methods are very good for this fault detection and classification. Still the best preferred ones are the methods described in [10] and [11].

2.5 Comparative study of CWT and DWT for Fault Classification

The choice of mother and daughter wavelets plays a very important role in the analysis. Mostly the db4 wavelet is preferred due to its accuracy in determining transients [9]. Each method uses different approaches to determine the faults by using transients in signals. When a fault occurs, the current in the line suddenly increase, or the voltage suddenly rises. We take these values of currents and voltages and get the energy from them.[1-2][10]. This energy change is then used to determine the types of fault. There are transients occurring in this particular energy instants, which are then used to perform DWT operation.

A training sequence has to be used in some methods like method involving DWT along with SVM [9] and the method with combination of DWT and ANN [11]. A comparison of CWT methods and DWT methods is tabulated in Table 1.

Table1.Comparision of CWT and DWT for various types of faults

Fault Type	CWT		DWT
	Mexican Hat	Coif let	
L-G	Higher accuracy than conventional ANN method	More accurate than Mexican hat method	Highest accuracy using all the available algorithms
L-L	More accurate than conventional methods	Higher accuracy	Most efficient with all the algorithms, except for B-C fault.
DL-G	Cannot be detected	Cannot be detected	High efficiency using all DWT algorithms when used along with SVM
L-L-L	High Accuracy	Highest accuracy amongst available	High accuracy using all DWT algorithms when used along with the SVM.

3. Conclusions

From the comparison of the discussed methods we find that though Mexican hat wavelet based method is best for the analysis of L-L-L fault, DL-G fault cannot be identified by it. The method involving DWT along with the SVM gives lesser efficiency of L-L-L fault identification; still it gives very high accuracy for other types of fault. Thus we conclude that this method is most appropriate one for transmission line fault detection and classification. In future scope we can say that the methods suggested can be also extended for localization of faults.

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