FAULT DETECTION IN EHV TRANSMISSION LINE USING SINGULAR VALUE DECOMPOSITION

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Abstract—Extra high voltage (EHV) transmission line network plays an important role in transmission line system. To maintain continuity and stability in extra high voltage transmission lines we have to detect the fault as fast as possible. The main challenge is to detect the faults which arise in EHV transmission line systems more efficiently. In this paper singular value decomposition (SVD) technique is used to detect the faults. SVD is a mathematical technique which reduces the risk of magnifying noise and more robust to numerical error. Also SVD can detect the faults in EHV lines even in high resistance conditions. MATLAB results are compared with discrete wavelet transformation (DWT) technique and its results shows effectiveness of this method. The performance of the proposed algorithm is tested under variety of fault conditions on a typical 500kv transmission line.

Index terms — Extra high voltage (EHV) transmission line, fault detection, discrete wavelet transform, singular value decomposition.

I. INTRODUCTION

FAULT detection is the one of the most important task involved in transmission-line relaying. They must be accomplished and as fast and accurate as possible to DE energize the system from the harmful faults and restore the system after faults. Faults may occur in high frequency transients current signals. The traditional algorithms was employed from many researchers which is based on steady-state components, have some problems in accelerating protection speed and it has some impact on fault type, fault inception time, fault resistance. Based on fault transients, several algorithms have been reported for fault detection. The fault-generated transient components, which contain abundant fault information and are immune to the system’s inconstancy, have been widely used in the fault detection. Wavelet transform (WT), which is the perfect time-frequency localization ability, has been chosen as an effective tool for analysing the fault transients Since the extra high voltage transmission line high frequency current signals are non-stationary and random in nature so that it is very difficult to extract the information on it. Generally, WT consists of successive pairs of low- and high pass filters. For each pair, the high-scale and low frequency components are called approximations, while the low-scale and high-frequency components are called details. The approximations and details form the WT-coefficient matrix that we need. It has moving window analysis technique to give the statement regarding to its frequency as well as time. The continues wavelet transform (CWT) and discrete wavelet transform (DWT) are the two forms of wavelet transform, we can choose any one of it but its depending upon the way the dilation and translation functions are used. The DWT is more advantageous then CWT, because DWT decomposes the signal into discrete family of frequency band that do not overlap each other, while in CWT decomposes the signal into its continues family that could overlap each other. Several algorithms are available for fault detection in transmission lines. Most of them have been developed for relaying purposes and may only distinguish a fault from the normal steady-state power system operation. WTs are well suited for the analysis of the non-stationary signals measured by the protection devices; WT has the ability to perform local analysis of relaying signals without losing the time-frequency information. WT is used in to capture the high-frequency traveling waves for fault detection, classification, and phase selection of faults. Discrete wavelet transform (DWT) based technique in detail and pointed out that DWT is an excellent online tool for relaying applications. Wavelet multi resolution analysis (MRA) is the computing algorithm used by DWT with the automatically adjusted window to extract sub band information from fault transients. Wavelet modulus maxima (WMM) is another technique to analyse the initial modal current traveling waves, and an effective approach to fast and accurate fault detection and fault phase selection has been achieved. Although the WT performs well in the transient Analysis and some improvements have been achieved in fault detection by using WT, there are still several open problems to be solved. In many applications WT is limited to show several fancy pictures and its transformed results still contain a large number of data which need further processing. However, these techniques are dependent on huge samples and trainings for knowledge representation, leading to an excessively complicated job. Also, they cannot manage the uncertain factors in the transmission system which will influence the reliability of fault detection.
In this paper, singular value decomposition is a mathematical technique that has application to many problems. SVD is an important tool in several different applications. Generally, the SVD finds application in problems involving large matrices, with dimensions that can reach into the thousands. It is the existence of efficient and accurate computer algorithms for its computation that makes the SVD so useful in these applications.

II. DISCRETE WAVELET TRANSFORM

The Discrete Wavelet Transform provides sufficient information both for analysis and synthesis of the original signal. The DWT is considerably easier to implement when compared to the CWT. It reduces the computation time sufficiently and easier to implement. Analyze the signal at different frequency bands with different resolutions and decompose the signal into a coarse approximation and detail information. DWT decomposes the signal into discrete family of frequency band that do not overlap each other, while in CWT decomposes the signal into its consecutive family that could overlap each other.

The function \( f(x) \) is a sequence of numbers

\[
\mathcal{G} = \left\{ \sum_{n=0}^{m} \sum_{k=0}^{n} a_n(k) \phi_{n,k}(x) \right\}, \quad m \leq n
\]

where \( a_n(k) \) is an arbitrary starting scale

\[
W_n(f, k) = \frac{1}{\sqrt{m}} \sum_{n=0}^{m} f(x) \phi_{n,k}(x)
\]

called the approximation or scaling coefficient

\[
W_n(f, k) = \frac{1}{\sqrt{m}} \sum_{n=0}^{m} f(x) \phi_{n,k}(x)
\]  

called the detail or wavelet coefficients.

III. SINGULAR VALUE DECOMPOSITION

Singular Value Decomposition (SVD) is a powerful and effective tool to extract special features in linear algebra. SVD is a factorization of \( A \) in to product of three matrices. For any \( m \times n \) matrix \( A \), an \( m \times r \) column orthogonal matrix \( U \), a transpose of an \( n \times r \) orthogonal matrix \( V \), and a \( r \times r \) diagonal matrix \( \Lambda \) consequentially exist, which enable \( A \) to be equivalently represented in the SVD form

\[
A = U \Lambda V^T
\]  

Where

\[
\Lambda = \begin{bmatrix}
\lambda_1 & 0 & \ldots & 0 \\
0 & \lambda_2 & \ldots & 0 \\
\vdots & \vdots & \ddots & \vdots \\
0 & 0 & \ldots & \lambda_r
\end{bmatrix}
\]

and its diagonal elements \( \lambda_i \) (i=1,2,……,r) are called “singular values” of matrix \( A \). The rank of matrix \( A \) is equal to the number of non-zero singular values of \( \lambda_i \). The columns of \( U \) (\( u_1, \ldots, u_n \)) are called the left singular vectors. The columns of \( V \) (\( v_1, \ldots, v_r \)) are called the right singular vectors. The singular values are all nonnegative and arranged in a non-increasing order (i.e., \( \lambda_1 \geq \lambda_2 \geq \ldots \geq \lambda_r \geq 0 \)). It is well known that various intrinsic Algebraic properties of a matrix operator can be revealed by SVD and can be represented by its singular values. If matrix \( A \) represents the time-frequency information of the fault transient, the matrix \( A \) will represent the basic modal characteristics of \( A \). Therefore, we use SVD to analyse the obtained DWT coefficient matrix and provide briefly numerical representation for the time–frequency distribution of the fault transient.

IV. FLOW CHART AND ALGORITHM FOR SINGULAR VALUE DECOMPOSITION IS GIVEN BELOW:

a) Flowchart for SVD Technique:

![Flowchart for Fault detection using SVD technique](image)

In this process, firstly zero sequence current or zero sequence voltages are calculated. Then that voltages and current are gone through four level of
decomposition based on mother wavelet ‘db4’. Now this four level of decomposition values are formed into a matrix and that matrix is subjected to singular value decomposition. The singular values thus obtained are compared with threshold values and then the status of fault is detected.

b) Algorithm of DWT and SVD:
Let f(x), which is a discrete sequence with samples, be the signal sequence to be analysed as follows:

1) First, analyse the f(x) by DWT, where the “db4” mother Wavelet and 4-scaled DWT are chosen in the transformation. Then, a 4 DWT-coefficient matrix can be obtained by means of (2) & (3).

2) Second, decompose the matrix A with SVD, and a singular-value array can be obtained as, \{λ1,λ2,...,λr\} where r is the rank of the diagonal matrix Λ. The value of r may be very large and the value of λi as well as its embodied information will decrease with the increase of i. In order to reduce the computing cost and keeping the hypostasis of Λ, the tiny singular values are neglected.

V. FAULT DETECTION TESTS IN SIMULATIONS

A typical model of a 500-kV and 300-km, 50Hz EHV transmission line with two power sources. The frequency-dependent (phase) mode is chosen as the transmission-line model in order to obtain more accurate results during transient simulations since the feature that the different frequency component has for a different attenuation degree is incorporated into this model. Under the normal condition, the positive-sequence parameters and zero sequence parameters are r₁=0.035Ω/km,x₁=0.424Ω/km,b₁=2.726×10⁻⁶S/km, and r₀=0.3Ω/km,x₀=1.143Ω/km,b₀=1.936×10⁻⁶S/km respectively. Assume that a single-phase-to-ground fault occurs at 5ms. Set the sampling frequency to be 20 kHz. Then, the zero-sequence current and voltage signals can be obtained and the SVD can be calculated.

A large number of simulation tests are carried out and the results are show that the SVD bears good capability for fault detection in EHV transmission line.

The comparison with DWT and couple of comparisons; 1) in the case of SVD the error of the detection result can be reduced and the adaptability of methodology can be improved; 2) in most conditions, faults can be detected more rapidly by SVD than by other algorithms; 3) Also SVD can detect the faults in EHV lines even in high resistance conditions and compared with discrete wavelet transformation (DWT) technique and it is proved that SVD technique is more effective because its fault detection time is less. Therefore, SVD is better and more applicable than most of the other previous methodologies in terms of fault detection.

The simulation results are shown in below figs.3&4
The contrast of the two methods applied to fault detection in EHV transmission line (R is the fault resistance; d is the fault location. In order to prove the superiority of SVD, it is compared with discrete wavelet transform (DWT).

CONCLUSION

In this paper SVD technique is used to detect the fault detection in EHV transmission line. The proposed technique is tested on 500kv two ended transmission system simulation studies are carried out for different fault conditions like fault resistance, fault location and different times. These results are compared with DWT technique under low resistance fault conditions. SVD technique detects the faults faster than DWT technique. Under high resistance faults conditions DWT does not detect the faults. But SVD technique detects more accurate. The entire algorithm is done by using MATLAB/SIMULINK.

REFERENCES

[1] Zhengyou He, Member, IEEE, Ling Fu, Sheng Lin, and Zhigang Bo, Senior Member “Fault Detection and Classification in EHV Transmission Line Based on Wavelet Singular Entropy” IEEE TRANSACTIONS ON POWER DELIVERY, VOL. 25, NO. 4, OCTOBER 2010


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