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REVIEWS ON DIFFERENT FAULT LOCATION CALCULATION METHODS ON TRANSMISSION LINE

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Abstract - The location of faults in high voltage transmission line compensated by series compensated device is a challenging problem. In recent years different researchers have attempted to address to this problem using different methods. The paper proposed different method of calculation of fault location on transmission line. And compare all and come to the solution that the kalman filter is more accurate method for calculation of fault location in transmission line. Intelligent technique for fault location using combined kalman filter and AI technique is proposed in transmission line with Series compensation which provides promising results. This paper gives general overviews of fault location calculation on the transmission line using the different fault location techniques.

Keywords - Different methods of fault location calculation, Wavelet transform, Fourier transform, Kalman filter

I. Introduction

Fault on the transmission line needs to be clear as early as possible and the early it is restored, for reduce the risk of power outage, damage of equipment of grid, complaint from customer and repair cost. Fault in power transmission line are difficult to detect and difficult to find the location of fault in transmission line due to its long structure. The Fault in transmission line is difficult to detect by using conventional overcurrent, ground fault relays and some version of distance relaying schemes. Diversity, uncertainties, selectivity, suitability and operational constraints introduce malfunction, limitations and detection errors in case of high impedance faults (HIF). HIF faults are usually characterized by the ripple rich current harmonic content due to non-linearity and thus are abnormal events that frequently occur in distribution feeders.

II. Different Fault location techniques:

The different fault location technique which has been reviewed are as follows:
i) Impedance based method
ii) Travelling wave method
iii) Wavelet transform method (WT)
iv) Fourier transform method (FT)
v) Fast fourier transform method (FFT)
vi) Kalman filter method

2.1. Impedance based method:

The impedance based method has two categories:
(1) Single ended algorithm
(2) Two terminal algorithm [1]
(i) Synchronized – collect by GPS, PMU. It requires communication channel
(ii) Unsynchronized – calculate synchronize error and fault location calculation.

The simplest method for finding the fault location in transmission line is impedance measurement method. In this method of fault location, the phasor voltage and current from generation end are known. Two terminal algorithm do not depend on the Fault resistance and source impedance therefore this is more accurate compare to single ended algorithm. Now assumed that the fault occurs, recorded phasor voltage and current are taken from both the ends. This Fault distance are calculated using impedance based method [2]. Due to presence of low or no current in high impedance fault (HIF), the conventional over current protection scheme fails to detect the fault and location of fault in transmission line. There for it is challenging issue to detect the HIF and isolate the feeder [16]. The main disadvantages of impedance based fault location calculation is when in more than one conductor if fault occur in single conductor then fault current have more than one path then the impedance of from both side are different than the fault location cannot find accurately by this method. The cost of this method is very low compare to other method of fault location calculation [2]. The impedance based method does not require the communication channel between the relays. If the fault distance is calculated using reactance of the line from one end than the location of fault cannot define accurately because of the fault resistance. If the fault occur is ungrounded than the resistance of fault is small and it does not affect the correctness of the fault location. And if the fault is grounded than the fault resistance will high and it will affect the precision of fault location [2]. For fault location estimation so far we neglect the shunt capacitance of transmission line. These estimation is quick good for short open conductor line. While in EHV and HV transmission line the shunt capacitance is large, in this situation the charging currents would be substantially and therefore the initial estimation would have large error. The estimation can be improved by using outline in this section [1].

2.2. Travelling wave method:

The second method for fault location calculation is travelling wave method. When the fault is occurring the fault current is record. In many cases when the fault occur large impedance mismatch is possible, this generate transient waves that travel through the lines reflected between the fault and the line end, from measurement of first two consecutive transient arrival times, fault can be find out. In other methods waves are observed from both the ends of the lines. Travelling wave method have fast response and high accuracy. The wave head is key to travelling wave fault location. If the wave head cannot be captured successfully then the fault location will fail. Accuracy of travelling wave method in fault location is depends on the sampling frequency. If fault occur near the line end, it is very difficult to identify the wave head at the line end due to the high speed of wave head. If the fault start then the voltage is zero, there is not abrupt change of the line continuity and a wave head is not produced [3].
The recorded fault current was transformed into two types: Ground mode and aerial mode. The ground mode is significant only in grounded fault occur and aerial mode is significant for all other types of faults. The main disadvantages of travelling wave based method for fault location calculation is transmission line might have multiple reflections from the bus and transformer. The travelling wave method is accurate. And also find out the fault location within a few seconds after the fault is occur. But this requires the expensive and new technological tools. Traveling wave speed is close to speed of light. Therefore high sampling frequency should be used to capture such fast waves, it requires expensive equipment [2].
Currently the most commonly method used for fault location calculation is determine the apparent reactance of the transmission line during the time that fault current is flowing and to convert the ohmic result into distance based on line parameters of the transmission line. This method gives the error when the fault arc is unstable, the fault resistance is high and the line is fed from both the end. This method is unsuitable for series compensated transmission line and give not clear results [3, 4].

2.3. Wavelet transform (WT) method:

The wavelet transform (WT) also can be used for analyze the transient behavior of a signal in both time and frequency domain. In this paper the wavelet transform split a given signal into a detail and an approximation by passing the signal through the combination of high pass and low pass filter. This process is repeat until the required level of decomposition is not achieved [5]. In power system many non-periodic signals that may contains sinusoidal and impulse transient components. For such type of signal time frequency resolution is needed. The spectrum of transient signals cannot be extracted by the fast Fourier transform (FFT). For overcome this limitation of FFT, wavelet analysis used instead of FFT. Wavelet transform is suitable for wideband signals. In mother wavelet the scaling parameter is inversely proportional to the frequency [2]. Wavelet transform gives us a multi-resolution analysis in time and frequency that is for high frequency we can get the good resolution compare to the low frequency. The Discrete Fourier transform (DFT) gives us better result of fault distance estimation under more than one phase are involved in fault. Time taken for the estimation of fault distance by discrete wavelet transform (DWT) is 72% more than the DFT fault location method [6].

The impedance based method has the high error compared to travelling wave based method. The travelling wave method has low error for ungrounded fault where as higher error for the grounded fault [2]. The DWT can be used very effectively for parameterization and characterization of the fault signal and neural network can be used for the classification of fault. The wavelet transform decomposes transients into a series of wavelet components, each of components which corresponds to a time-domain signal that covers a specific frequency band containing more detailed information. The wavelet transform is capable for trading one type of resolution into another resolution, which makes them especially suitable for the analysis of non-stationary or transient signals. The main advantages of the wavelet transform are that it is able to demonstrate the local feature of a particular area of a large signal. Wavelet transform divides up data, function into different frequency component and then study each component with a resolution matched to its scale [7]. In the wavelet transform signal is passed through the series of high pass and low pass filters, and this process is repeated until required level of decomposition is achieved. The level-3 approximated signal (A3) is lower frequency components as compare to the level-1 approximate signal (A1). Both approximation and related fault voltage are extracted from the original signal with the multi resolution analysis [7].

In this paper author found that the different mother wavelet is not affect the overall performance of the proposed algorithm significantly. It is also observing that more non-zero element can provide better performance in terms of the accuracy of the phase shift. In this paper author use the maximal over loop discrete wavelet transform (MODWT) to extract the fundamental frequency component of the voltage and current signals measured by the digital relays [8].

In this paper author use the wavelet transform and artificial neural network for the fault location finding in transmission line. The extraction is used to transform high dimensional data into lower dimensional data and reduce the complexity of classification of regression scheme. In this paper authors have utilized the six level decomposition of the voltage and current signals [5].

Dynamic wavelet transform is implemented by way of the six-level filter bank. The result gives that the WT is more accurate compare to the FT. In this paper WT is compared with the window Fourier transform. Compare to window FT, WT use short window at high frequency and long window at low frequency, therefore the advantageous of arbitrary high time resolution at high frequency and arbitrary high frequency resolution at low frequency. The error is lower compare to Fourier transform [9]. The continuous WT of a signal f(x) depends on scale parameter or frequency parameter a, and time or position parameter b. The ψ is called mother wavelet which satisfy

$$\int_R \psi(x)dx = 0 \qquad [1]$$

It is given by

$$wf(a,b) = < f, \psi_{a,b} > = \int_R f(x)\psi_{a,b}(x)dx$$

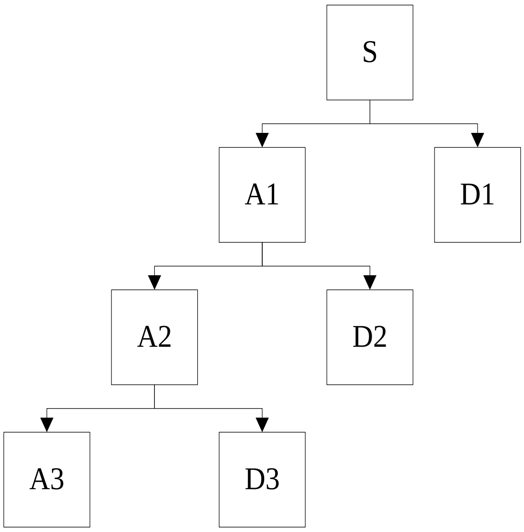

Fig 1. Wavelet decomposition tree [7]

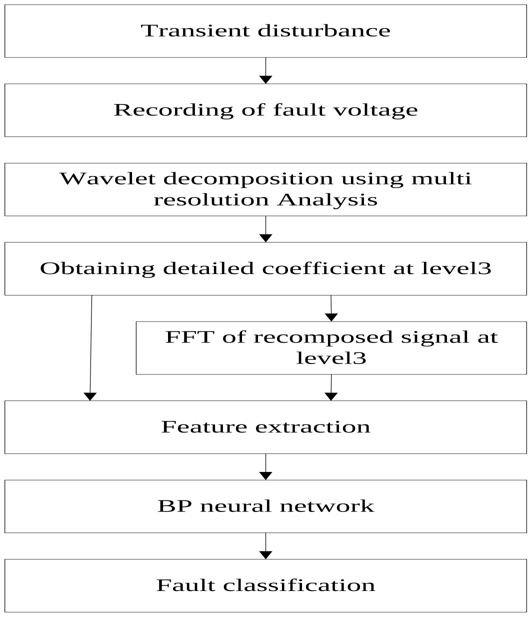

Fig 2. Procedure of Fault analysis [7]

Where the real function is

$$\psi_{a,b}(x) = |a|^{-1/2}\psi\left(\frac{x-b}{a}\right) \qquad [3]$$

2.4. Fourier transform (FT) method:

The Fourier transform gives us information about all frequencies present in the signal it gives no indication as to when in time were signals present. The FT is basic tools for DSP and also simplest one for the fault location calculation. The discrete Fourier transform give the better result during the L-G fault which is most common fault in transmission system. The combination of both discrete Fourier transform (DFT) and discrete wavelet transform (DWT) also use for the fault location calculation. In the hybrid system the DFT is used for calculation of fault distance for the L-G fault while the DWT is used for calculation of fault distance for more than one line include in the fault [6]. Fourier transform method is easy to implement but it has its drawback, such as that it is dependent on sample from a whole period, which makes prediction relatively slower [10].

The FFT is used to calculate voltage and current phasor in actual digital protective relays. Most of the algorithm are based on the voltage and current phasor. However, the disadvantages of DFT is it produce error when exponential decaying DC offset are present, and introduce tendency of overreaching and under reaching. This problem mainly presents in current signal. In this paper the second order Taylor-Kalman-Fourier filter is proposed for reduce the negative effect of the exponentially decaying DC offsets in the distance relays. Therefore T^2FT filter improves the relays impedance estimation under faulted conditions. By using T^2FT filter transient and steady-state response of relays are improve with compare to the DFT filter [11]. An algorithm is created based on the Fourier analysis has been developed for an accurate fault location in a UHV and EHV transmission line. And fault location is unaffected by the fault resistance [12].

2.5. Fast Fourier transform (FFT) method:

In this paper author give the numerical comparison between FFT and Kalman filter applied for harmonic components detection of grid operation under different situation. The most common tools for spectral analysis is the FFT due to its high efficiency computational implementation. The FFT has some issues and give incorrect information when it is used incorrectly. The FFT has computationally efficient for the stationary waveforms but some pitfall for non-stationary waveform [13].

Here, interpolation method for the non-uniform Fourier transform that is optimal in the min-max sense of minimizing the worst-case approximation error over all signals of unit norm. The FFT requires only $N \log N$ operation for an N-point signal, whereas DFT requires N^2 operations. Therefore, FFT has fast algorithm compare to DFT [14].

2.6. Kalman filter:

The extended kalman filter is a nonlinear time domain stochastic estimator that provides an efficient estimation of the harmonic component of fault current under a high impedance fault (HIF), characterized by ripple rich current harmonic content due to nonlinearity. This paper proposed on a numerical comparison between Fast Fourier transform (FFT) and Kalman filter applied for harmonic components detection in different situation of the grid operation. The kalman filter gives better behavior compare to the FFT in non-stationary signal also. The kalman filter depends on the grid frequency ω_k to extract the harmonic component [13].

The kalman filter is a simply a recursive data processing algorithm in the form of a set of equations that provides an efficient computational means to estimate the behavior of a process, in a way that minimize the means square error (MSE). The mean square error is difference between the actual output and the estimated output. Track the variation of system parameter by updating its weight on-line when the system experiences disturbances or different operating conditions [15].

The paper present for fault detection using extended kalman filter (EKF) and support vector machine. This proposed approach uses the magnitude and phase change of fundamental, 3rd, 5th, 7th, 11th and 13th harmonic component as feature input of the support vector machine (SVM). SVM has advantages over other is efficient in terms of speed. It gives excellent result even during the noisy conditions and also can be extracted for large power distribution network [16].

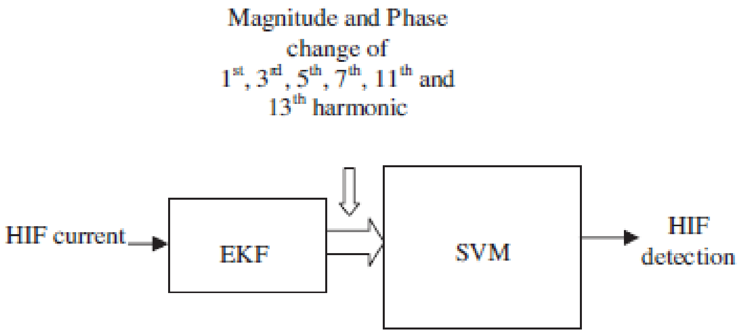

Fig 3. Proposed HIF detection scheme [16]

This paper proposed an extended complex kalman filter and employs it for the estimation of power system frequency in the present of noise and distortion. The method uses the sampled values of 3-phase voltage as input. And the $\alpha\beta$-transform is used to convert these input to a complex observation vector. The EKF approach is used to compute the true state of the model iteratively with significant noise and harmonic distortions. In this paper, a variation of nonlinear kalman filter in the complex form is presented which simplified the modeling requirement for frequency and amplitude estimation of a signal. It works good for step changes and decay or rise in system frequency [17].

This paper describes the design and the test results of a kalman filtering based on digital distance protection scheme. For the estimation of voltage states two state kalman filter is used while for the estimation of current states three-state kalman filter is used, because for current state estimation exponentially decaying component is including. The kalman filter has advantages that low computer burden of the computation of the states [18].

This paper proposed an optimal method for tracking the harmonics in power system voltage or current waveforms. In this kalman filter is used to estimate the harmonics of a distorted measurement signal. The performance of kalman filter is depends on noise covariance matrix Q and R. in the proposed scheme Q and R is tuned. The kalman filters response time is investigated under sudden change of magnitude and phase of one of the harmonics present in the signal [19].

This paper proposed an integrated approach to design harmonic estimator of a PWM converter in the presence of harmonic parameter variation with low signal to noise ratio. The comparison with FFT shows that the performance of EKF is superior. The EKF accurately estimate the frequency and magnitude of harmonic components presented in voltage and current waveform with noise. The performance of the filter is poor when signal to noise ratio is lower [20].

III. Conclusion

The kalman filter gives the better result compare to all other method of fault location calculation under the non-stationary signal and noisy condition also. The accuracy of kalman filter is more than Fourier transform method and all other methods. The Fourier transform give the accurate frequency information but it is not efficient for non-stationary fault. The kalman filter has lower computer burden compare to all other method because it not need all the previous data. KF gives faster estimation compare to other fault location method. It produces efficient result even during the transient and estimate voltage state as well as current state also.

IV. References

[1] M. Sachdev and R. Agarwal, "A technique for estimating transmission line fault locations from digital impedance relay measurements," *IEEE Transactions on Power Delivery*, vol. 3, pp. 121-129, 1988.

[2] S. Ghimire, "Analysis of Fault location methods on transmission lines," 2014.

[3] L. De Andrade and T. P. De Leão, "Travelling wave based fault location analysis for transmission lines," in *EPJ Web of Conferences*, 2012, p. 04005.

[4] P. Gale, P. Crossley, X. Bingyin, G. Yaozhong, B. Cory, and J. Barker, "Fault location based on travelling waves," in *1993 Fifth International Conference on Developments in Power System Protection*, 1993, pp. 54-59.

[5] A. M. Paikrao and A. S. Pande, "Fault Location on Transmission line using Wavelet Transform and Artificial Neural Network."

[6] D. Das, N. K. Singh, and A. K. Sinha, "A comparison of Fourier transform and wavelet transform methods for detection and classification of faults on transmission lines," in *2006 IEEE Power India Conference*, 2006, p. 7 pp.

[7] P. Bhowmik, P. Purkait, and K. Bhattacharya, "A novel wavelet transform aided neural network based transmission line fault analysis method," *International Journal of Electrical Power & Energy Systems*, vol. 31, pp. 213-219, 2009.

[8] F. Liang and B. Jeyasurya, "Transmission line distance protection using wavelet transform algorithm," *IEEE transactions on power delivery*, vol. 19, pp. 545-553, 2004.

[9] X. Yibin, D. C. T. Wai, and W. Keerthipala, "A new technique using wavelet analysis for fault location," 1997.

[10] B. Bukh, U. S. Gudmundsdottir, P. B. Holst, K. B. Jensen, L. C. Jensen, and C. L. Bak, "Advantages in using Kalman phasor estimation in numerical differential protective relaying compared to the Fourier estimation method," in *International Conference on Power Systems Transients (IPST'07) in Lyon, France*, 2007.

[11] A. Zamora-Mendez, M. R. A. Paternina, E. Vázquez, J. M. Ramirez, and J. A. l. O. de Serna, "Distance Relays Based on the Taylor–Kalman-Fourier Filter," *IEEE Transactions on Power Delivery*, vol. 31, pp. 928-935, 2016.

[12] T. Takagi, Y. Yamakoshi, J. Baba, K. Uemura, and T. Sakaguchi, "A New Alogorithm of an Accurate Fault Location for EHV/UHV Transmission Lines: Part I-Fourier Transformation Method," *IEEE Transactions on Power Apparatus and Systems*, pp. 1316-1323, 1981.

[13] N. C. Will and R. Cardoso, "Comparative analysis between FFT and Kalman filter approaches for harmonic components detection," in *2012 10th IEEE/IAS International Conference on Industry Applications*, 2012, pp. 1-7.

[14] J. A. Fessler and B. P. Sutton, "Nonuniform fast Fourier transforms using min-max interpolation," *IEEE transactions on signal processing*, vol. 51, pp. 560-574, 2003.

[15] A. Albakkar, A. Barnawi, and O. Malik, "Adaptive FACTS controller based on kalman filter estimator," in *2009 International Conference on Electric Power and Energy Conversion Systems,(EPECS)*, 2009, pp. 1-6.

[16] S. Samantaray and P. Dash, "High impedance fault detection in distribution feeders using extended kalman filter and support vector machine," *European Transactions on Electrical Power*, vol. 20, pp. 382-393, 2010.

[17] P. Dash, A. Pradhan, and G. Panda, "Frequency estimation of distorted power system signals using extended complex Kalman filter," *IEEE Transactions on Power Delivery*, vol. 14, pp. 761-766, 1999.

[18] A. A. Girgis, "A new Kalman filtering based digital distance relay," *IEEE Transactions on Power Apparatus and Systems*, pp. 3471-3480, 1982.

[19] R. Reddy, S. Nakka, and S. Sonam, "Estimation Of Power Harmonics Using Kalman Filter," *Int. J. Res. Appl. Sci. Eng. Technol*, vol. 5, pp. 1251-1257, 2017.

[20] D. V. Anilbhai, "MAGNITUDE AND FREQUENCY ESTIMATION USING EXTENDED KALMAN FILTER," *Development*, vol. 2, 2015.