Estimation of Fault Distance in Transmission Line Using DWT Algorithm and GIS

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***Abstract* - The Electrical Power service providers distribute the power supply to the consumer without any interruption whenever fault occurs, so Geographical Information System (GIS) provides good facilities for presentation of fault location results in both graphical and report form. So to pinpoint the power line fault location can easily visualize with the help of GIS. The work involves the mapping of electrical network in GIS, fault distance estimation using Matlab and finally visualize the fault position in GIS. In this work based on Discrete Wavelet Transform (DWT) and Travelling Wave theory, the location of fault in the three phase power transmission line is estimated.**

Keywords: GIS for Electricity, Power line Fault, Discrete Wavelet Transform, Electrical network mapping, Signal transient, Disturbance of power system

I.INTRODUCTION

Transmission line faults are mostly triggered by falling trees across power lines, lightning stroke, insulator strings to flash over. Economically more reliable operation of power system requires fast fault location and fast fault clearing as soon as possible. Here to estimate the fault location faster by using pre and post fault components. The estimation of fundamental components of current signal requires for application of this robust algorithm against the undesired effects of produced transient components due to occurrence of fault in power line. It improves the operational speed of conventional techniques for identification of faults. The electrical network mapping can be done with GPS survey [1].Recently Discrete Wavelet Transform has used widely for estimating the fault location very accurately [2]. The fault distance can be estimated with Travelling wave theory [3] [4] [5]. The GPS survey can be done with stand alone GPS device [6]. The most important characteristics of DWT for analyze the waveform on time-scale domain rather than frequency with limited discrete values. A typical simple transmission line is taken and it is analyzed in this work. The transmission line is subjected to Line to Ground fault at a particular time instant. The fault location technique is proposed and analyzed through DWT method with daubechies5 mother wavelet. The transmission line model is simulated on MATLAB/SIMULINK. It is found that the DWT method is most accurate in locating the fault position of transmission line and it requires only limited number of samples not all the values of signal. The result obtained from the case studies based on data presented by the Tamil Nadu Electricity Board.

II. GIS IN ELECTRICAL NETWORK

Traditional electrical system analysis has performed within the electric system software itself. These tools are highly successful and satisfactory for calculation of load flow, protection device settings, short circuit analysis, harmonic analysis, etc. In addition it is importance to recognize that the information required for perform these calculation is also utilized in other forms of system management. For example, to establish protective device setting for a distribution feeder, to locate the fault position, Cable length, Configuration, Material, Size and planning for expansion needs to know information on the feeder to determine the available capacity for growth. The location or spatial information is examined through a variety of spatial attributes such as distance, proximity and elevation in GIS. For instance, to identify the fault location of power line there are certain environment, social and infrastructure related criteria needed to fully assess the situation. In GIS these factors would be virtual layers of information that are draped over the existing electrical system.

A. Discrete Wavelet Transform

The Discrete Wavelet Transform is defined as per the equation (1).

$$DWT[m,k] = \frac{1}{\sqrt{a_0^m}} \sum_n x[n]\, g\left[\frac{k - n a_0^m}{a_0^m}\right] \text{------------}(1)$$

Where g[n] is the mother wavelet (in this work Daubechies5 is selected as mother wavelet), and the scaling and translation parameter is a and b are function of an integer parameter m, $a=a_o^m$ and $b=na_o^m$

Discrete Wavelet analysis which is a mathematical tool for signal processing is used to detect the type of fault occurring on the transmission line. The DWT is introduced as a method to analyzing the electro-magnetic transients created in power system faults and switching. This method such as Fourier transform provides information related to the frequency composite of a waveform, but it is more appropriate and precise than the familiar Fourier method for non-periodic, wide-band signals associated with electro-magnetic transients of signal. DWT possesses some unique features that make it very suitable for this particular application. It transforms the given function from the time domain into time-scaling domain. The basis function used in the DWT is band pass characteristics which makes this transforming similar to a mapping to the time-frequency plane. Unlike the basic functions used in Fourier analysis method, the wavelet transforms are not only denoted in frequency but also in time-scale. This localization allows the detection of the time of occurrence of abrupt disturbances in faulty signal. DWT reduces the time of computation sufficiently. It is easier to implement and analyze the signal at different frequency bands with various resolutions. And it decomposes the signal into coarse Approximation and Detail coefficient. The low frequency components are representing the Approximation and high frequency components are representing the Detail.

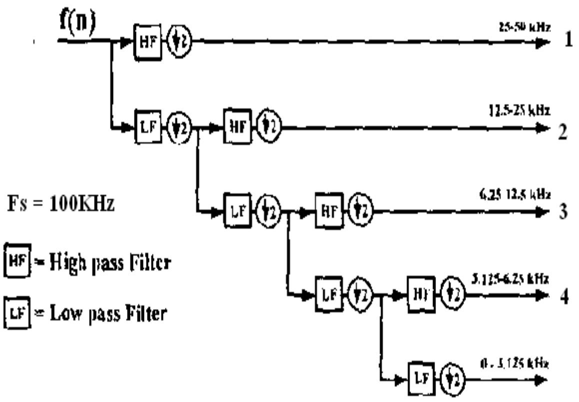

Figure 1.Discrete Wavelet transform from scale 1 to scale 4.

Translation and scale is important factor in wavelet transform. Translation is related to the location of signal at every point, as the window is shifted along the signal. This term corresponds to time related information of signal in the transform domain. Scaling implies the increases or reduces the width of the mother wavelet. The high scale corresponds to the non-detailed global view of the signal and low scale represents the detailed view. So high scale implies that stretches the mother wavelet and compared it with original signal and produces low frequency components and low scale compress the mother wavelet and compares then produces the high frequency components. Scaling is a mathematical operation that either dilates or compresses the signal. The frequency of the signal and scale is inversing in wavelet transform. Figure 1 shows the different scales in DWT output.

III. CASE STUDY

The field work is carried for over head power transmission line feeder with the voltage range of 110KV and the total length of 10.2KM from Sholinganallur substation to Velachery substation. The power transmission has been carried out by Aluminum Conductor Steel Reinforced (ACSR) through 44 transmission tower. This power line crossed over water bodies, road network, agriculture land and settlements. This transmission line is simulated by the Matlab as per parameter given in Figure 2

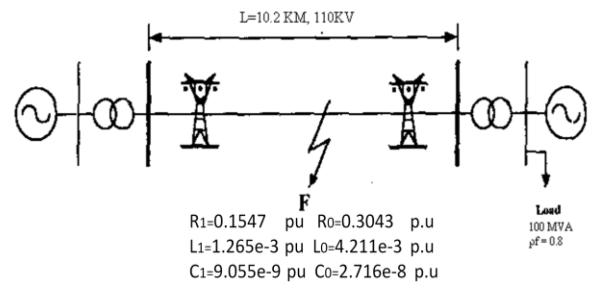

Figure 2.Transmission line.

The geo-spatial data collected for transmission tower, bus-bar and substation performed by the Global Positioning System (GPS) survey. Proper GPS survey and creation of an accurate digital base map to the electrical network is very essential for a successful GIS implementation. The latitude and longitude of the electrical asset used to create vector map in GIS. This asset survey carried out by direct inspection of all the assets. Non-spatial data required for this work is collected from various department of Tamil Nadu Electricity Board. Those data are line resistance, reactance, type of conductors used, number of towers and load dispatch from receiving end. In order to operate with GPS it is importance that the GPS antenna has clear view to at least four satellites.

A. Data Processing in GIS

The whole process of this work is illustrated in Figure 3.The digitization of electrical network assets mapping involves the following procedure:

- GPS survey of electrical network assets: This involves the global address identification of electrical asset and Geo-reference the high resolution satellite image for study area.
- Digitization of electrical network assets like substations, bus-bar, Transmission towers, Power line and other land features like water bodies, agriculture land, settlement, empty space. Then make the electrical connectivity plotted on base map.
- GIS mapping and codification of electrical network assets made with defined electrical relationships.
- Create the spatial and Non-spatial database.
- Linearly reference the Transmission route in GIS.

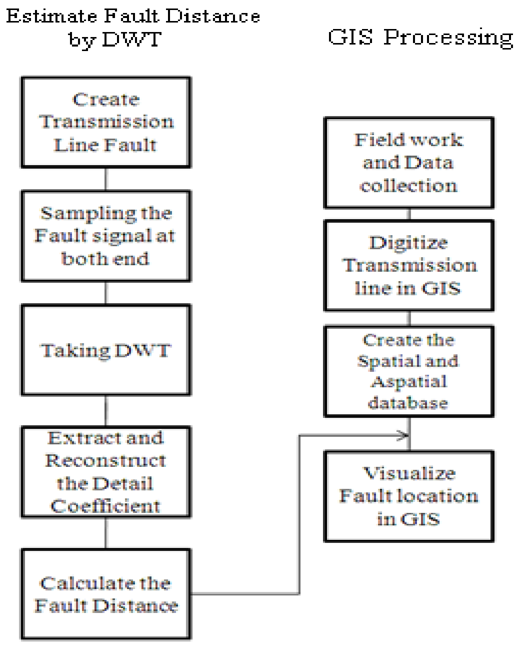

Figure 3.Processing

B. Fault Detection

When fault occurs, the current at both sending and receiving end used for analysis of this work. Due to the fault, the normal current waveform will abruptly change and it is analyzed by DWT. The distortion of the normal waveform depends mainly on the type of fault. Faults are simulated for the transmission line with phase to ground faults for various distances. Sample the faulty waveform signal at 1MHz rate. Take the one dimensional DWT for both sending and receiving end waveforms of the sampled faulty signal. This work is carried out with Daubechies5 filter as a mother wavelet, so approximation and detail coefficients are produced for first level decomposition. Extract the detail coefficient and reconstruct it similar to original waveform. It has more accurate to identify the time of occurrence at first level decomposition. Take the first peak value from the reconstructed detail coefficient of high frequency component at both end and identify the time of occurrence of peak.

To determine the fault location, the time of fault signal is used to reach at each end of the transmission line with first level decomposition. The travelling wave theory is applied in order to calculate the fault distance as per the equation (2). The fault signal and the result of detail information for both ends are shows in Figure 4. The percentage of error is calculated as per the equation (3) and the Table1 shows the result of DWT based fault distance estimation.

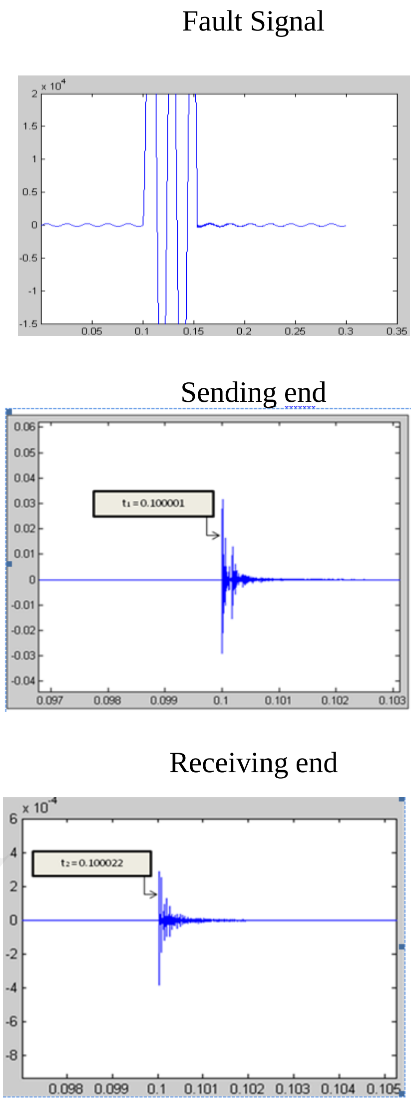

Figure 4.Fault transient signal

$$d = \frac{L + (t_1 - t_2)\,V}{2} \quad \text{------------(2)}$$

d – Fault distance

L – Total length of the transmission line

t1 - The time at which the fault in sending end is detected

t2 - The time at which the fault in receiving end is detected

V – Velocity of the travelling wave

$$\%\ \text{of Error} = \frac{\text{Calculated Distance} - \text{Actual Disance}}{\text{Line Length}} * 100 \quad \text{-------------(3)}$$

Table 1.Fault distance estimation

Actual Distance(Km)	Transient time(t1)sec	Transient time(t2)sec	Calculated Distance(Km)	Percentage Error
2	0.100001	0.100022	1.997	-0.029
4	0.100005	0.100012	4.065	0.637
5.2	0.100010	0.100009	5.248	0.470
6	0.100012	0.100006	5.986	-0.137
7.3	0.100020	0.100005	7.316	0.156
8	0.100021	0.100001	8.054	0.529

IV. RESULT AND CONCLUSION

The computer program is used to estimate fault distance with DWT technique and locate the fault position in transmission line using GIS. Figure 5 shows the final result of pinpointing the fault location in transmission line that is easily visualized in GIS with the help of satellite Image. So the surrounding environment can be easily identified with geo-referenced high resolution satellite image and the mapping of electrical network. Moreover, accurately estimated fault location can help to speed up the crews work, reduce the total number of stand by crews, maintenance cost and reduce the time of power supply interruption. GIS provides facility to locate the fault in inaccessible area like Wetland, Forest and Sea. As a result the reliability of the power system will be increases.

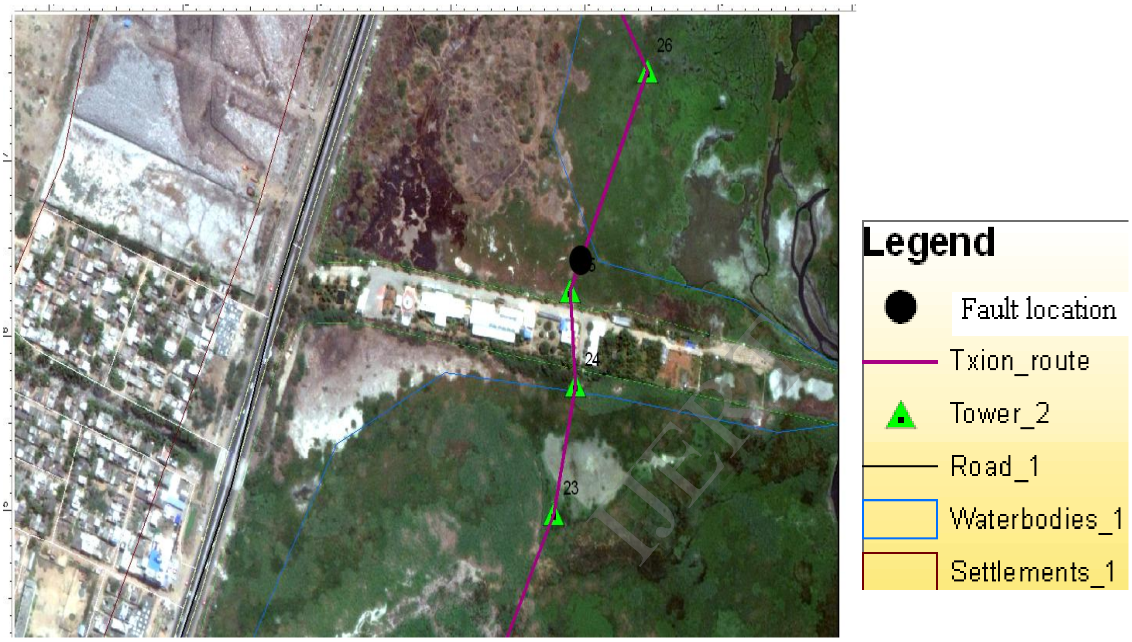

Figure 5.Pinpointing the fault position in Satellite Image

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