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Location of Fault in a Transmission Line Using Single Ended Travelling Wave

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Abstract: Power system is mostly affected by the faults which are occurred in the transmission line and cable. Nowaday, it is very necessary to locate and detect the faults quickly in order to get better performances. Travelling wave fault location technique has more no of merits to avoid the complexity and minimizes the cost. In this strategy the faulted distances are calculated by the help of arrival time and propagation velocity. Single ended measurements have certain merits over multi ended measurements. In this study, a new technique is applied which uses the wavelet transform and travelling waves to locate the fault distance in transmission lines. Simulation models have been done to conform the effects of the used methods which depend on the wavelets. Results show that the used method is able to locate the faults more accurately.

Key words: Travelling Wave (TW), Wavelet Transform (WT), Discrete Wavelet Transform (DWT), Fourier Transforms (FT), complexity, simulation

INTRODUCTION

Mainly the transmission line failure is due to lightning, storm, freezing, rain and snow, insulation damage. In addition, these external objects such as branches and birds are factors that lead to short circuits (Saha *et al*., 2009). It is difficult to avoid the faults. In the past, it may take several hours to find the location of fault. Especially, flashover transient failure is more difficult to find. Therefore, the fault location has become a hot topic for many years in the power system study. In order to store the systems without any changes in their reliability an advanced fault location technique is required which minimizes the time with required amount of cost related to the dispatched centers. It is very necessary to mitigate the faults as quickly as possible forreliable services to the consumer in addition to restore the installation.

Several studies have been done to detect and locate the faults on transmission lines. There are many techniques for fault location out of these techniques we are mainly considering two types (Ngu and Ramar, 2011) which are used in the overhead transmission lines and underground cables: impedance based technique (Santos and Senger, 2011; Pereira and Zanetta, 2007; Kandari *et al*., 2011) and traveling wave based technique (Jung *et al*., 2012; Abur and Magnago, 2000; Faybisovich and Khoroshev, 2008; Styvaktakis *et al*., 1999; Yongli *et al*., 2004; Gilany *et al*., 2005). Traveling wave fault location strategies are considered as the most correct strategies as compared to the impedance based strategies and these are not affected by the source impedance, fault resistance and power flow (Styvaktakis *et al*., 1999). Travelling wave technique is more reliable, stable and more accurate. It should be single ended or multi ended. The single ended travelling wave based technique calculates the fault location by taking the time difference between two consecutive peaks of the captured signals then that time difference is used for locating the faults. The main challenge of travelling wave is to identify the fault sections. Traveling wave fault location technique is divided into: time domain analysis and frequency domain analysis (Ji *et al*., 2009; Samani *et al*., 2007). Arrival time of the travelling wave is derived by the processing of the wavelet coefficients. The used approach is decreasing the impacts of the propagation velocity. The accuracy of travelling wave based fault location technique is completely depended on the arrival time and propagation velocity of the of faulted wave.

WT approach may be used to find the arrival time of the travelling waves. Here, we are using single ended fault location strategy for combined transmission lines. Different modes of traveling wave have different transmission velocity. Discrete Wavelet Transform (DWT) is very helpful for analyzing the interaction of the harmonic frequency and the travelling wave. Wavelet coefficients of scale 5 of the signal are used for locating the fault points and distinguish grounded faults from

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ungrounded faults. A wavelet based technique of fault location scheme for cable systems is used by Santos and Senger (2011) where modal analysis and DWT are analyzed. Wavelet analysis is an effective time frequency signal processing tool. Similar to fourier transformation that produces the projection of signal in frequency domain, wavelet analysis is the projection in time frequency domain.

MATERIALS AND METHODS

Travelling wave theory: Principle of traveling wave method is based on the traveling high frequency signals of the voltage and current recorded on the terminal bus. In particular, the distance between the initial and subsequent peaks of the terminal bus is utilized for calculating the distance of the faulted points. It is assumed that the faults occur on the single-phase transmission lines of the bus system at both ends. According to the superposition theory, two equal amplitude and opposite directions are superimposed on the fault point. The amplitude of the two voltage sources is equal to the magnitude of the pre-fault voltages. The post-fault network of a single-phase transmission line power system can be considered as a superimposed circuit for the normal operation of the network before the fault and an additional faulty component network.

Depending on the wave theory, the single ended mode uses the wave generated by the fault to see the fault location. The device of this mode is barely put in at one end of the bus and no communication system is required on the opposite bus end. Single ended mode requires easier equipment than double ended but, this mode is suffering from the transmitted waves. The single ended resistance methodology is employed to estimate the position to get a tiny low variation of fault location. This variable is then required to indicate whether or not the mirrored wave is for the purpose of failure or from the way finish. The V and I signal data are recorded by the simulation system. Then, the point where the maximum value of the detail coefficient appears is the exact crest position, so that, the number of samples of the crest is the point position of the maximum modulus. Depending on the theory by Idris *et al.* (2012), once the cable fails, the waves are in 2 directions and from the aim of failure. It's going to still rebound between the failure and every ends of the bus, until the fault is in the stable state. If the propagation velocity of the wave is found, the area from the fault at any station unit is typically calculated. The velocity of the wave gives its value (Inductance (L) and Capacitance (C)). The fault location is found due to the propagation velocity of wave (Chen *et al.*, 2006; Jin *et al.*, 2008; Sushama *et al.*, 2009). Transient waves may manufacture different frequency components on the buses. So as to look out the dominant frequency, a pair of ways that area unit wide used (Darban *et al.*, 2017) .The first methodology is that the Spectral Estimation, followed by the WT at this analysis, WT is utilized to extract frequency from transient waves. Daubechies wave is utilized to watch and realize interference events. Daubechies wave has many filter coefficients, like 4, 6, 8 and 10 db. If a_1 and a_2 are the first and second peaks, respectively. Then, the velocity:

$$V = \frac{2\times \text{The distance taken}}{\tau\times(a_1-a_2)} \tag{1}$$

The value of v is nearly equal to the velocity of light. Where τ is the sampling time fault location:

$$D = \frac{(a_1-a_2)\times V}{2} \tag{2}$$

Then:

$$\text{Error (E)} = \frac{\text{Actual distance-Calculated distance}}{\text{Total line length}}$$

Wavelet transform: Wavelets are used for maintaining the relation between time and frequency of the signals. Wavelet transform is very similar to fourier transform. Now, it is used for signal processing. The most important conditions of wavelets are it should be oscillating and it should be decaying to 0 as soon as possible. WT is considered as an important mathematical tool which is very useful to analyze the non-stationary signals such as those associated with faults or switching operations. An exact wavelet can be chosen depending on the types of applications. They are used in the power system (protection relays) which also helpful to detect high impedance faults and to identify faulted phases, locate the traveling wave faults and also protect the transformers. The signals will decompose into totally different frequencies and also the time location of each frequencies may be determined. The representation of WT of any type of signals or function f(t) is given by:

$$w_f(p, q) = |p|^{-(1/2)} \int_{-\infty}^{\infty} f(t)\Psi^*\left(\frac{t-q}{p}\right)dt \tag{4}$$

$\psi^*(t\text{-}q/p)$ is the conjugate function of the WT function $\psi(t\text{-}q/p)$.

RESULTS AND DISCUSSION

Simulation results and analysis: The technique of using travelling wave method of fault location is described here. The model and the calculations are done by the help of MATLAB/Simulink. The arrival time is taken for calculation of faulted distances from the two ends simultaneously. Here, we are considering three phase to ground fault. The V and I are sampled at a given frequency. Total length of the transmission line is 100 km (Fig. 1). Voltage: 800 kV. Power: 100 MVA. Length of transmission line = 100 km. Source inductance = 1.58 mH.

Figure 2 and 3 show the wavelet modulus maxima for the current signals for distance = 10 and 20 km, respectively. Figure 2 gives the first peak value is 2567 and the value of second peak is 2651 and Fig. 3 gives the first peak value is 2608 and the value of second peak is 2779. Figure 4-6 show the wavelet modulus maxima for the current signals for distance = 30, 40 and 50 km, respectively. Figure 4 shows the first peak value is 2653 and the second peak is 2907. Figure 5 gives the first peak value is 2693 and the second peak is 3035. Figure 6 gives the first peak value is 2736 and the second peak is 3163.

Figure 7-9 show the wavelet modulus maxima for the current signals for distance 60, 70 and 80 km, respectively and also presents the sample number for the first and second peaks of the travelling wave. Figure 7 gives the first peak value is 2780 and the second peak is 3291. Figure 8 presents the first peak value is 2821 and the second peak is 3418. Figure 9 gives the first peak value is 2866 and the second peak is 3546. Figure 10 shows the wavelet modulus maxima for the current signals for distance 90 km. It also presents the sample number for the first and second peaks of the travelling wave. The first peak value is 2906 and the second peak is 3674. The velocity of travelling wave is depended on the system

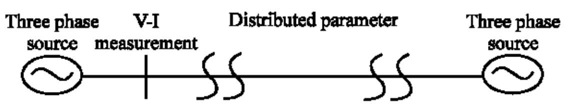

Fig. 1: Single line diagram of proposed model

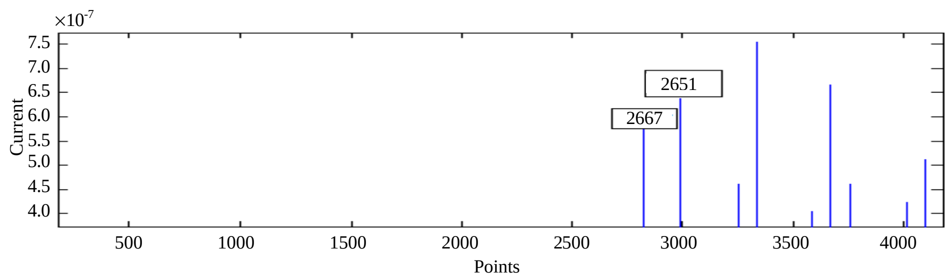

Fig. 2: For distance 10 km

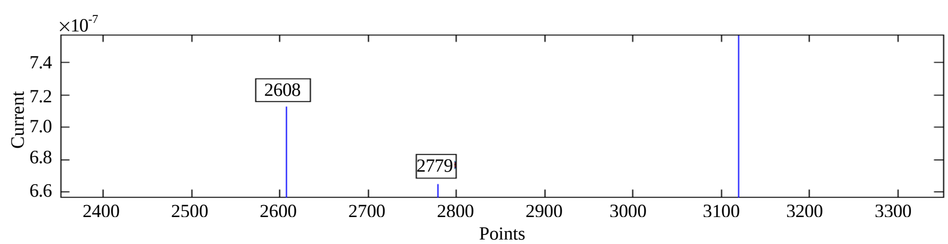

Fig. 3: For distance 20 km

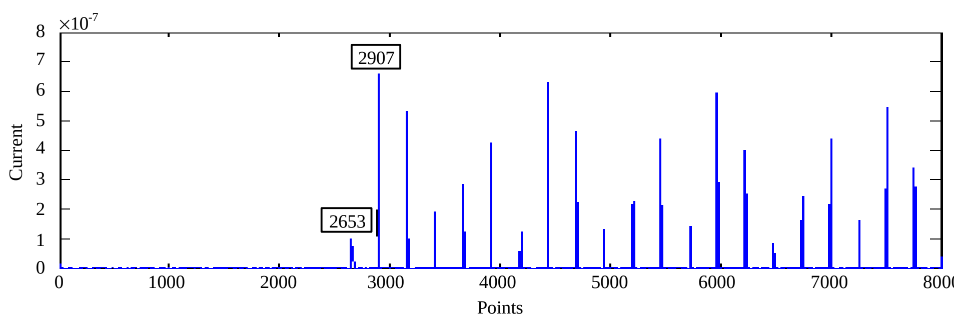

Fig. 4: For distance 30 km

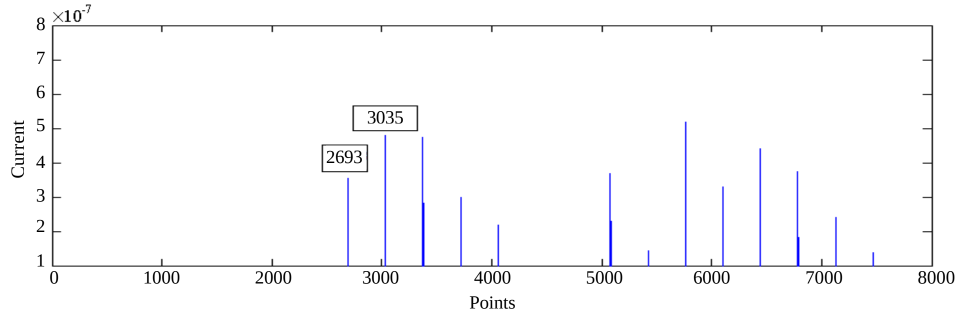

Fig. 5: For distance 40 km

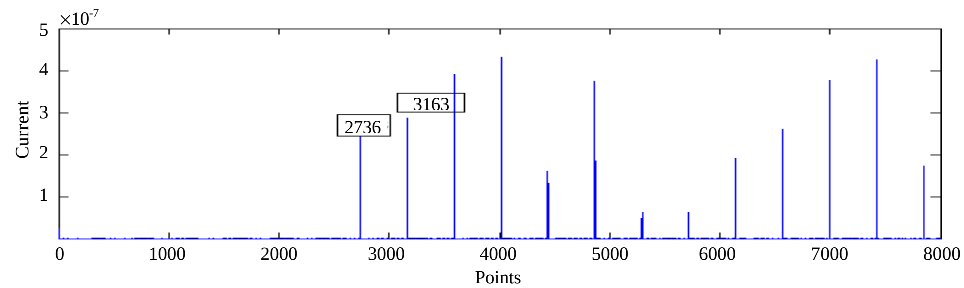

Fig. 6: For distance 50 km

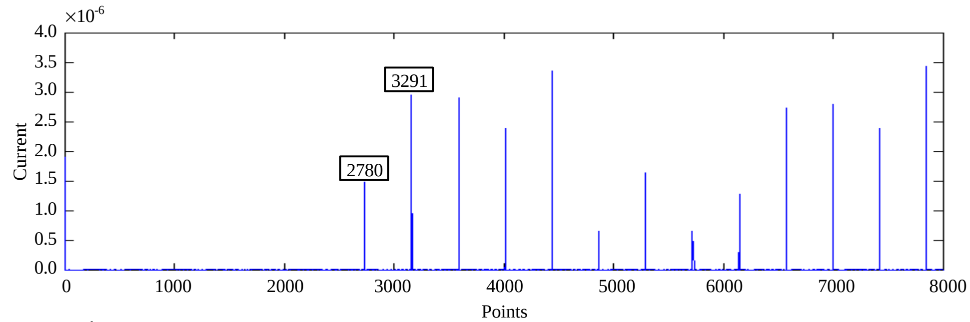

Fig. 7: For distance 60 km

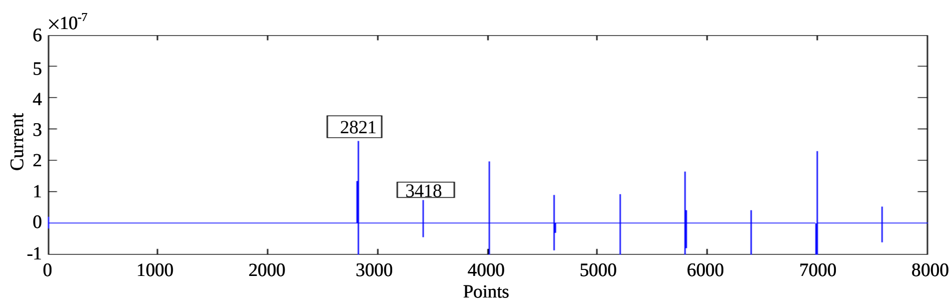

Fig. 8: For distance 70 km

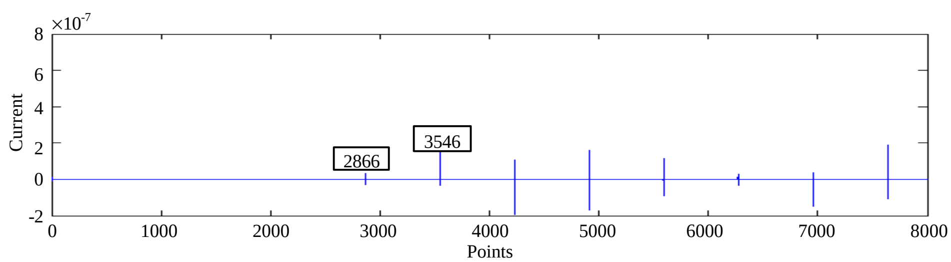

Fig. 9: For distance 80 km

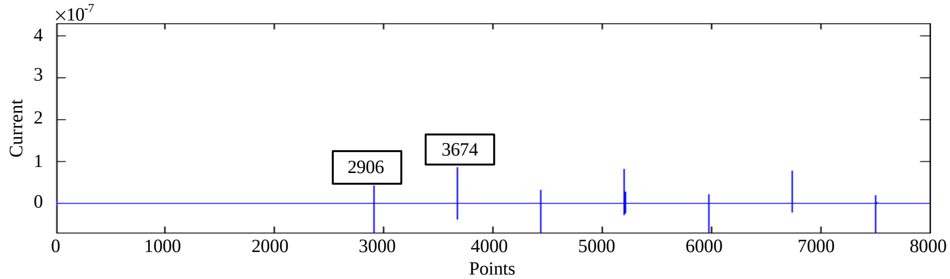

Fig. 10: For distance 90 km

Table 1: Calculation of fault distance

Distance (km)	a_1	a_2	Calculated fault (km)	Error (%)
10	2567	2651	10.038	0.038
20	2608	2779	20.430	0.430
30	2653	2907	30.350	0.350
40	2693	3035	40.860	0.860
50	2736	3163	51.020	1.020
60	2780	3291	61.060	1.060
70	2821	3418	71.340	1.340
80	2866	3546	81.260	1.260
90	2906	3674	91.780	1.780

Average error = 0.90%

Table 2: Calculation for velocity

Distance (km)	Velocity (km/sec)	Distance (km)	Velocity
10	2.35×10^5	50	2.30×10^5
20	2.29×10^5	60	2.78×10^5
30	2.32×10^5	70	2.63×10^5
40	2.29×10^5	80	2.31×10^5
		90	2.30×10^5

Average velocity = 2.39×10^5

parameters. Assuming that the transient time is 0.041-1 sec and three phase to ground fault occurs on the transmission lines. Table 1 and 2 give the estimation of travelling wave velocity for different fault location. Assuming that if here fault.

CONCLUSION

Fault on the transmission line causes power outage, losses and it may damage the components are used, so, it should be minimized as soon as possible. Many techniques are introduced to locate and detect the faults. Travelling wave it can calculate the fault distances in a few second. The main motive of this study is to represent the travelling wave fault location technique and calculate the faulted areas by using wavelet transform. By the help of first two conjugative peaks the fault location can be found. This model is not depended on the fault impedance. This method can also helpful for all fault types and different transmission line length. The simulation models are done by using MATLAB Software. Three phases to ground fault is used here for calculating the faulted distances. The error is below 2%. Simulation results are given to check the performances of the methodology. The distances for current signals are estimated by taking the average velocity is V = 2.39×10^8 km/sec. This table gives the average error = 0.90% which is <1%. The errors are large when the fault points are nearer to the end bus and the middle point of the transmission line.

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