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Original Article

Fault Analysis on Multi-Terminal System Using Wavelet Transform and Wavelet Morphing Technique

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Abstract - *This paper deals a peculiar method on power transmission protection system using wavelet multi-resolution analysis (WMA). For swift, accurate and exact location of fault detection and also find exact pin-point location of fault detection on proposed network novel wavelet morphing technique are implemented. Five-fatal network used to for recognition, cataloguing and exact pin-point location at any fault are detected using morphing technique. Preliminary sum of the detailed co- efficient of mother bior2.2 and coif1 are calculated and fault indices are obtained from these detail co-efficient. By using these fault indices all types of fault indices are obtained at different inception angle and at varies length on the line. These fault indexes are compared with the threshold value to detect and classify faults on transmission system. The proposed algorithm is proved for the detection, classification and location of faults on Transmission lines using wavelet morphing technique more effectively*

Keywords - *Power system network, Wind source, Wavelet multi-Resolution analysis, Wavelet morphing technique.*

I. INTRODUCTION

Wavelet morphing is one of the methods for fault detection, classification and location of faults on the proposed system. Many techniques are available for accurate fault detection. But compared to all methods results, wavelet morphing gives more efficient results. Power supply is interrupted by faults on the transmission lines. To supply uninterrupted energy to the consumers,quick detection and accurate estimation of fault detection techniques are needed. So here wavelet morphing technique has been implemented.

Wavelet transform techniques (WTT) are used for detecting the faults accurately. But here is the advanced method of WTT. That is wavelet morphing technique.WTT has different mother wavelets, mother wavelet are chosen for type of application [1]. Using Wavelet Transform and Morphing analysis, faults will be detected quickly, accurate and better results are possible. This technique has been implemented on the proposed multi terminal transmission system. Applying the WTT and WMT techniques, fault indices of all the three phases of post fault current signals were obtained and sum of the fault indices were obtained at different distances on the transmission line. There is always a need to develop pioneering methods for transmission line protection. In this paper, Wavelet based MRA has been used for detection, cataloguing and location of faults on transmission lines. Detail coefficients (DC's) D1 of current signals at both the ends were used to detect and classify the type of fault. For transmission system protection, there are different methods like time-graded overcurrent protection, differential pilot-wire protection and distance protection. For very long high voltage transmission lines time-graded and pilot-wire protection systems are not suitable. Differential protection scheme for long lines are more expensive. Differential relay are used for heavy and minor load connected faulty condition [2].

Suitable Protection scheme is needed not only for abnormal conditions but also against short circuits which may arise on a power system. Most of the transmission line faults are caused by short circuits occur due to the wind, natural calamities and many others [3]. A digital distance-protection scheme can control by analyzing the measured voltage and current signals using Wavelets [4]. New protection schemes are required to survive with the bi-directional power flow, availability of more numbers of Sources [5]. The proposed algorithm is designed for the protection of two area power system can be done by using wavelet based multi-resolution analysis[6] with bior2.2 and coif1 mother wavelets and combined Bior2.2 coif1 i.e., wavelet morphing technique. The protection method is tested under various possible types of faults on proposed power system network and it is found that the scheme has been working properly.

II. WIND SOURCE

Wind is midair set in motion by small amount of insolation reaching the higher atmosphere of ground [7]. Wind energy simply rehabilitated into electrical energy because it contains

Kinetic Energy. Wind energy is an indirect energy source. In wind mill generation Rotor play an important role. Wind mill components are design properly to get efficient output. Wind mill head supports the rotor bearing and rotor housing. For large aerogenerators, downwind rotors are specially prepared [7].

There are various techniques for fault detection and classification, like Fourier Transform, Fourier transform and Short Time Fourier Transform. But discrete Fourier It has various techniques for fault detection techniques, they were discrete Fourier transform, Fourier transform and short time Fourier transform. But discrete Fourier transform and Fourier transform both of these gives only data. Short time Fourier transform gives both time and frequency data also. But it doesn't gives better result for critical non-stationary disturbances like three phase and short circuit faults. For these reasons WT technique are chosen.

WT provides the time and frequency simultaneously and it is a linear transformation. WT are continuous, discrete and four -resolution techniques. Four -resolution are analyze time-and frequency for all type of faults accurately and gives efficient result that means more reliability and system stability. WT analyze the signal and it decompose the signal into dif- ferent frequency components and each frequency component will be analyzed with resolution matched to its scale. Higher and lower transients are analyzed [8]. The following function defined the (WT) function:

$$\varphi(t) = \sqrt{2} \sum h(n)\varphi(2t - n) \quad (1)$$

$$\psi(t) = \sqrt{2} \; g(n)\varphi(2t - n) \quad (2)$$

where

$$g(n) = (-1)^n h(1 - n)$$

Type of Mother wavelet is depends on the application to be carried and further apply multi-resolution analysis for detec- tion and discrimination of faults in the transmission Zones [9]. Wavelet morphing is a new technique for smooth transients. Wavelet has a different types of mother wavelets. These are Haar, Daubechies, biorthogonal, Coiflets, Symlets, Morlet, Mexican hat and Meyer. Among these only biorthogonal and Daubechies are taken. Bior mother wavelets are 14 types i.e., bior1.3, bior1.5, bior2.2 and so on. Coiflets mother wavelets are coif1, coif2, coif3, coif4 and coif5. Combination is not possible to any two mother wavelets. Morphing technique is possible between weighted vectors and these weighted vectors are obtained from each set of detail coefficients and singular decomposition. Here only chosen bior2.2coif1. Types of biorthogonal wavelets and Coiflets wavelets, Coiflets are 5 types and coif A. A represents numbers of vanishing moments. Biorthogonal wavelet don't conserve the energy at stage of application. It also have number of vanishing moments.

Above figures are bior2.2 and coir1 and combination of both bior2.2 and coif1 shown in fig3. Compare these waves, output result are changed and also obtained higher frequency distortion and accuracy also increased. Details coefficients of current signals are calculated using Bior2.2coif1 i.e., wavelet morphing technique and calibrated by sum of the detailed coefficients are used to detect, classify on two area power system network.

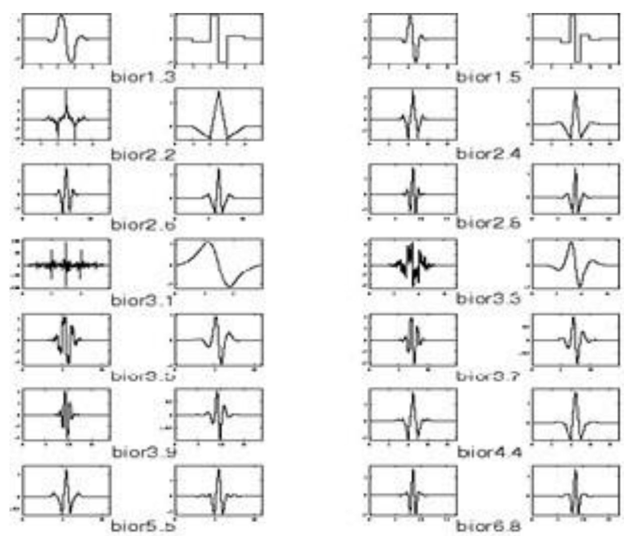

Fig. 1 Types of biorthogonal wavelet

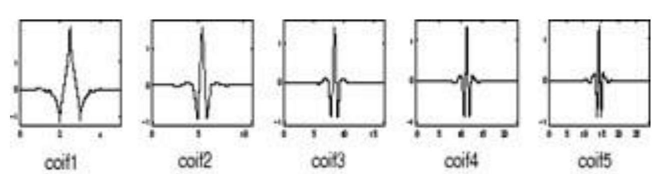

Fig. 2 Types of coiflet wavelet

III. SYSTEM MODEL AND ANALYSIS

The single line diagram is shown in the fig The.4 which has two 719MVA and two 700MVA DG's one 9MW wind farm. and system parameters are shown in table 1. The proposed system will be divided into eight zones different transmission lengths and 230KV transmission line. Symmetrical and unsymmetrical faults are applied on the system at long transmission lines. Here, long transmission lines are 110km and 220km lines. In wavelet based MRA, detail co-efficients are obtained from WTT using bior2.2 and coif1 mother wavelets are used. All these programs are run using MATLAB code. All symm. unsymm. Faults are created on long transmission lines. By using these programs sum of the detail co-efficients and fault indices are calculated at long transmission lines. Same process will be repeated for WMT, here used bior2.2 and coif1 combination. Sum of the fault indices are obtained from these fault index. At

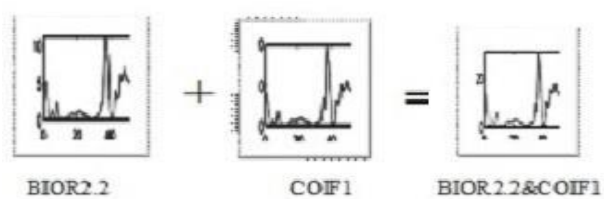

Fig. 3 Combination of Bior and Coieff Wavelets.

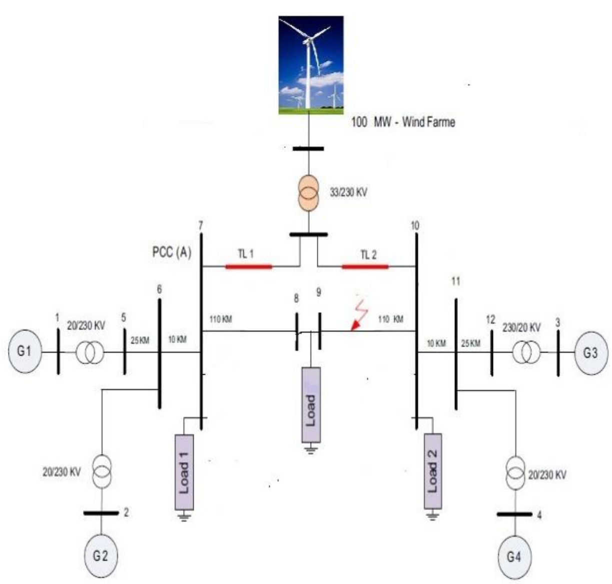

Fig. 4 Single line diagram of the proposed system

Table 1. Proposed system parameters

Terminal 1	DG-1:20Kv,719MVA
Terminal 2	DG-2:20Kv,700MVA
Terminal 3	DG-3:20Kv,700MVA
Terminal 4	DG-4:20Kv,719MVA
Terminal 5	Wind form:100MVA
Transmission line Parameters	R=0.01273 Ω, R_0 = 0.3864Ωnn L=0.9337mH,L_0 = 4.1264mH C=12.74nF,C_0 = 7.75nF
Transfor mer Ratings	20Kv/230KV,1000MVA
Mother Wavelets Frequency Sampling Rate	Bior-2.2,Coif1 192K hz 1920

each 10km's fault will be detected throughout the line. Here, threshold value also set at 35. Below 35 is a healthy fault and above the fault is unhealthy. SL-G, LL-G, L-L and LLL-faults are detected at two 110km and 220km line. At each cycle it gives 19200 samples. At each fault it will take 30 minutes time to run the program. All results are shown below.

IV. RESULTS AND DISCUSSION

Detail coefficients of fault indices are obtained from wavelet based MRA and three phase current signals are obtained. Fault indices w.r.t. time and fault at different lengths are shown at all types of faults. In fig.5-fig.7 are L-G fault index on zone-3. Fig.5 are the L-G fault on zone-3 bior2.2 mother wavelet are used. So, here fault accuracy at 200 and fault detected within 20msec. Same L-G fault index are observed on zone-3 using coif1 here fault accuracy detected at 300 and same time period. In fig.7 applied WMT on zone-3 accuracy are increased and smooth signal are possible. Compare to both it don't detect another line fault but WMT applied result are detected. Fig.8-

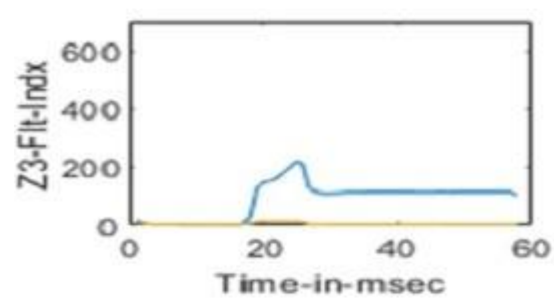

Fig. 5 L-G fault on zone-3 using bior2.2

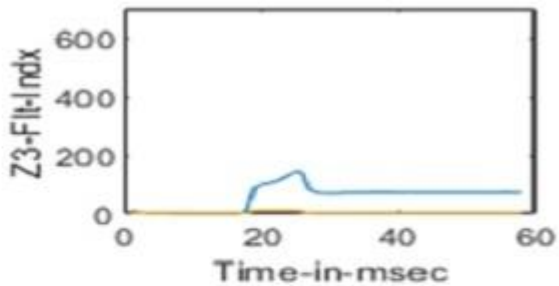

Fig. 6 L-G fault on zone-3 using coif1

Fig. 10 shows fault at different distances on L-G fault on zone-3, 110km transmission line. bior2.2, coif 1 and WMT results are obtained. In fig.8 fault accuracy at 90 and coif1 fault accuracy at 150. Here also compare these three results fault accuracy at 220 and each 10km's fault will be detected using WMT. Threshold value 35, below 35 is a healthy fault and th value is unhealthy fault.

Fig.11-fig.16 shows L-L fault on zone-3 using WTT and

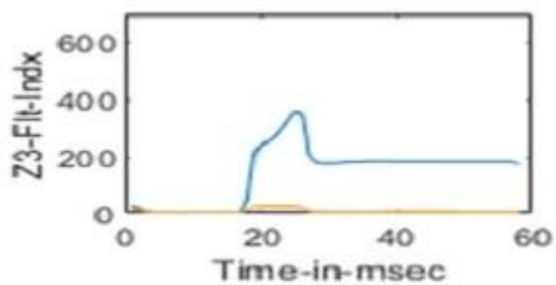

Fig. 7 L-G fault on zone-3 using morphing

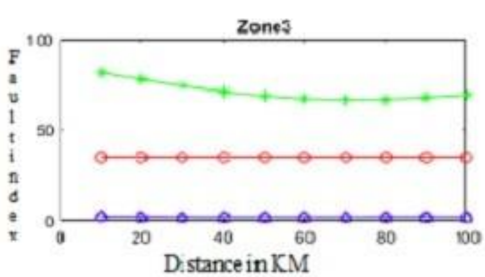

Fig. 8 L-G fault variation on zone-3 using bior2.2

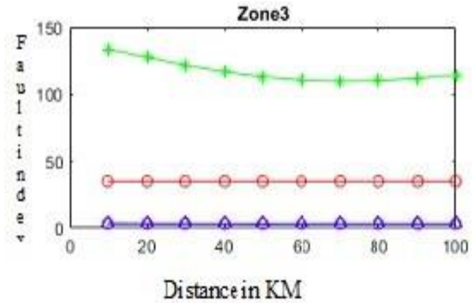

Fig. 9 L-G fault variation on zone-3 using coif1

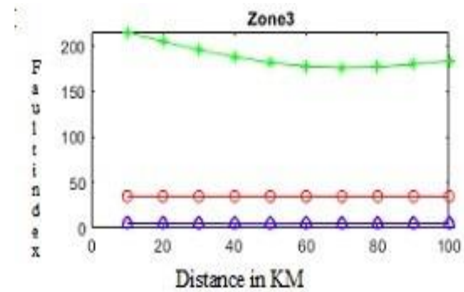

Fig. 10 L-G fault variation on zone-3 using morphing

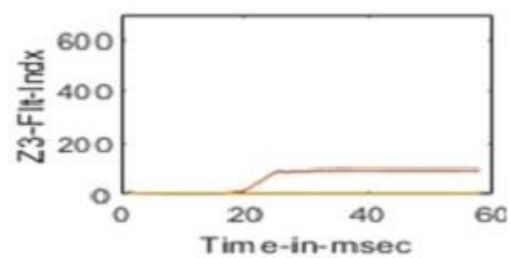

Fig. 11 L-L fault on zone-3 using bior2.2

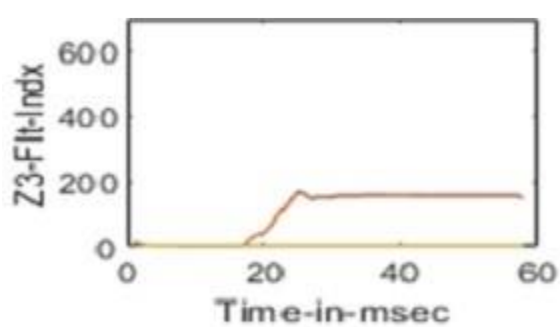

Fig. 12. L-L fault on zone-3 using coif1

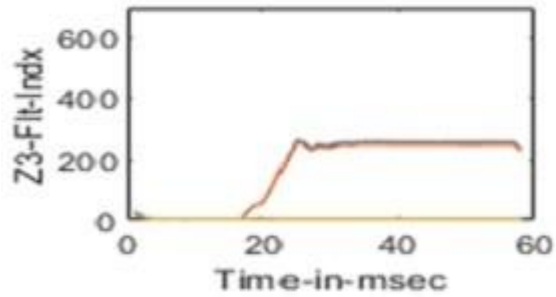

Fig. 13 L-L fault on zone-3 using morphing

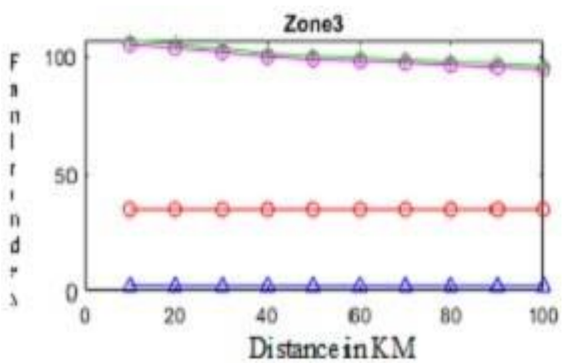

Fig. 14 L-L fault variation on zone-3 using bior2.2

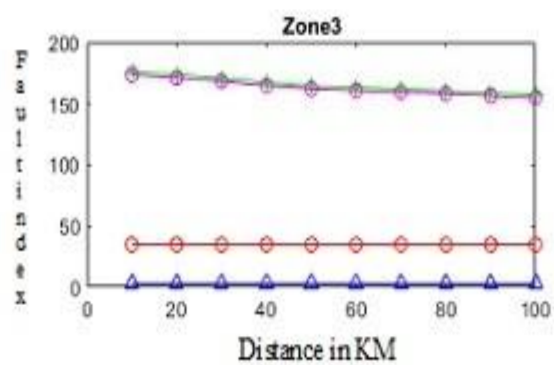

Fig. 15 L-L fault variation on zone-3 using coif1

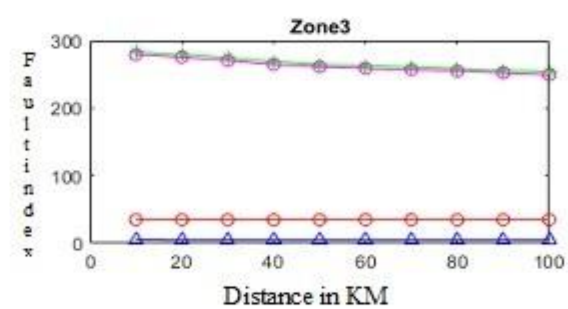

Fig. 16 L-L-L fault variation on zone-3 using coif1

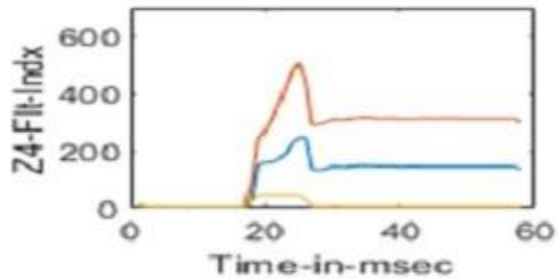

Fig. 17 L-L-L fault on zone-3 using morphing

WMT. Fig.11 shows L-L fault using bior2.2 detect the fault accuracy at 150 and detection time period below 20msec's and fig.12 shows L-L fault using coif1 detect the fault accuracy at 200 and fault detection time period at

before 20 msec but compare to bior2.2 detection time and accuracy are improved. In fig.13 shows same fault at same zone here fault accuracy is 300 and smooth signal are possible using morphing technique. Fig.14-fig16 shows fault variation at each 10km's, observed all the results more accuracy get at morphing technique and same fault don't continue throughout the line. at starting it is increased and going through the transmission line fault will be gradually decreased. Fig.17-fig28 shows LL-G and LLL.

fault on zone-4 using bior2.2, coif1 and morphing techniques. Fig.17 shows LL-G fault using bior2.2 fault and coif1 o/p in fig.18 fault are WTT. Compare to both more fault accuracy and smooth signal are possible by using WMT in fig.19. Fig.20- fig.22 show fault variation on zone-4 LL-G faults. Boir2.2, coif1 o/p's are given but compare to both more clarity and more fault accuracy are possible by using WMT. So, here

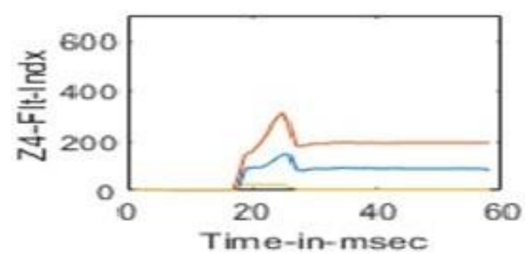

Fig. 18 LL-G fault on zone-4 using coif1

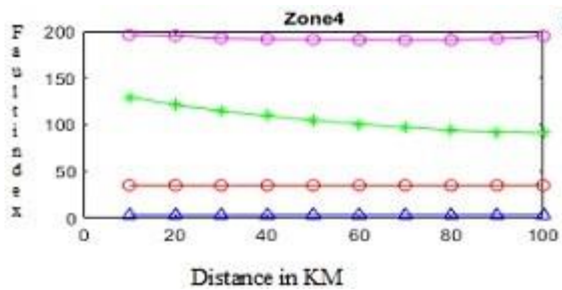

Fig. 19 LL-G fault on zone-4 using morphing

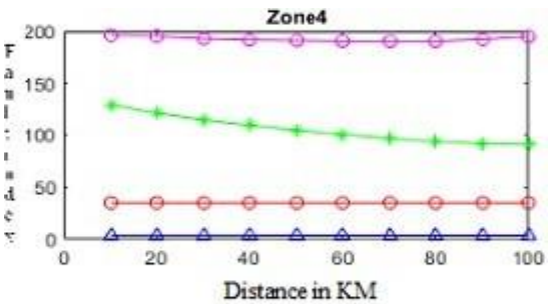

Fig. 20 LL-G varying fault on zone-4 using boir2.2

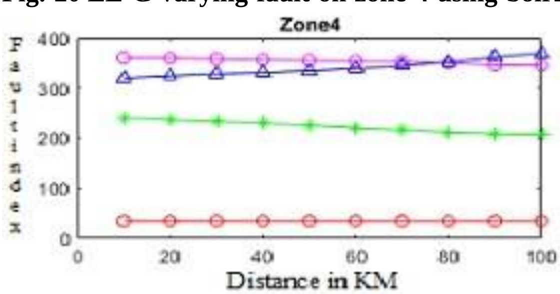

Fig. 21 LL-G varying fault on zone-4 using coif1

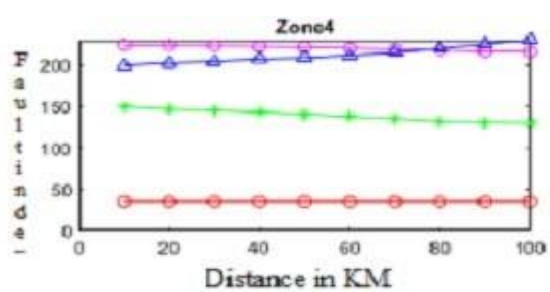

Fig. 22 LL-G varying fault on zone-4using morphing

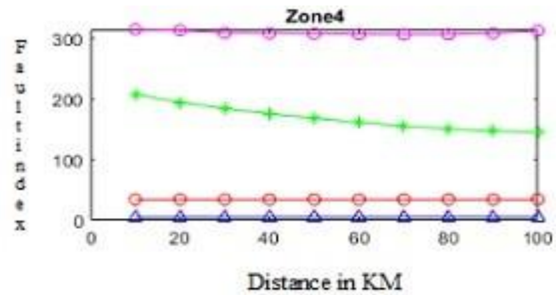

Fig. 23 LLL fault on zone-4 using coif1

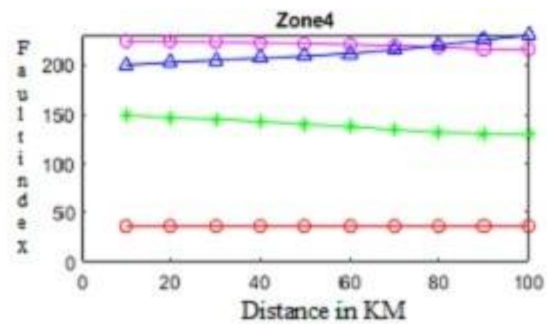

Fig. 24 LLL varying fault on zone-4 using bior2.2

phase-A fault accuracy at 200 and phase-B fault accuracy at 300. Phase- A fault are slightly decrease when increasing the distance, in phase-B fault nearly constant throughout the t/m/n line. Same kind of properties are obtained from LLL faults on zone-4. More accuracy, quick detection, clear signal and smooth signal and more efficient output are obtained.

Below given L-G and L-L fault on zone-7 its length is 220km. Here also WTT and WMT are applied. Th value set at 35 below the Th value is a healthy fault and above the Th value is a fault. Fig.29-fig34 L-G faults on zone-7 its length is 220km. in fig.29-fig.31 shows fault indices using WTT and WMT. Compare all three more fault accuracy found at WMT. In fig.32-fig.34 are the L-G fault on zone-7 using WTT WMT. It detect the fault at every 10km's on t/m/n line. WTT fault accuracy are less compare to WMT. And also at initial condition it gives more fault and gradually decreasing the fault and smooth, clarity fault detection are obtained from WMT.

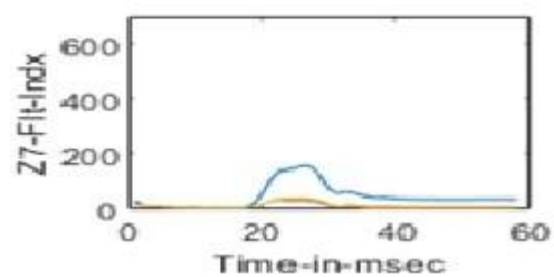

Fig. 25 L-G fault on zone-7 using bior2.2

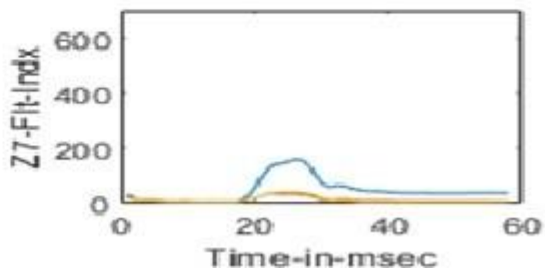

Fig. 26 L-G fault on zone-7 using ciof1

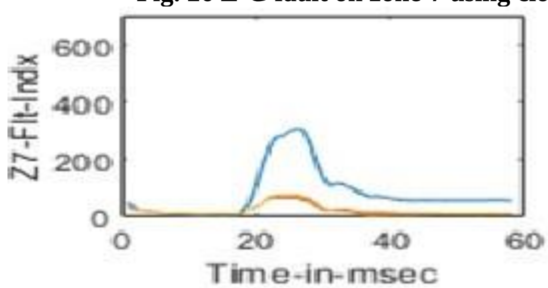

Fig. 27 L-G fault on zone-7 using morphing

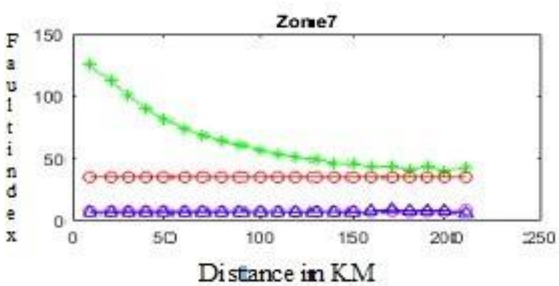

Fig. 28 L-G varying fault on zone-7 using bior2.2

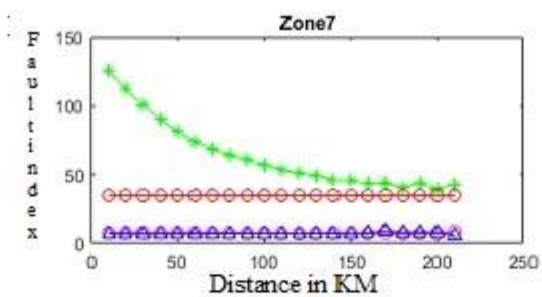

Fig. 29 L-G varying fault on zone-7 using ciof1

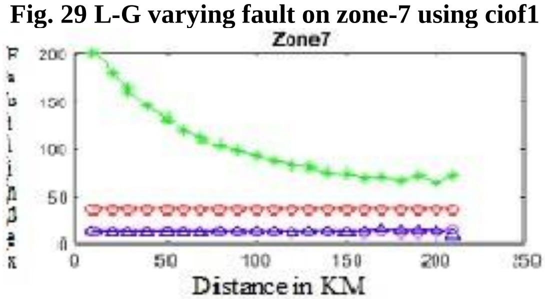

Fig. 30 L-G varying fault on zone-7 using morphing

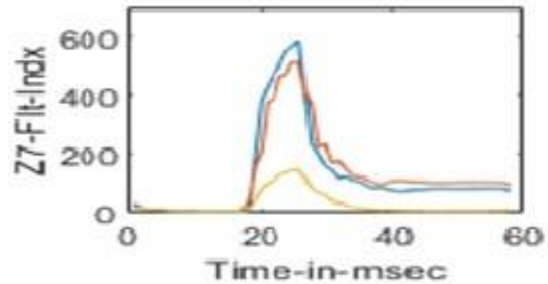

Fig. 31 LL-G fault on zone-7 using bior2.2

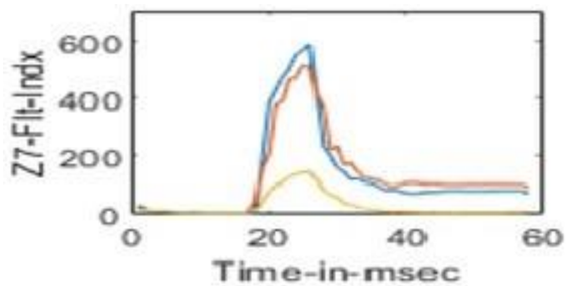

Fig. 32 LL-G fault on zone-7

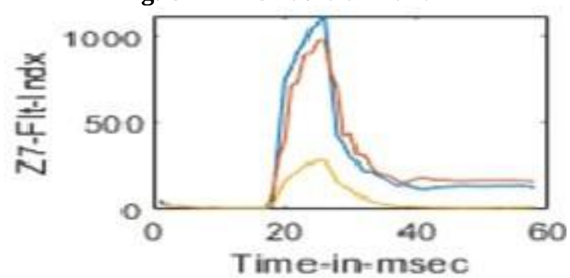

Fig. 33 LL-G fault on zone-7

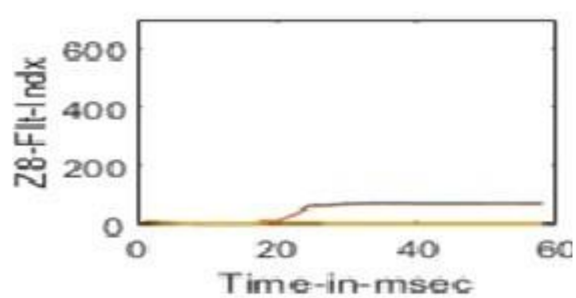

Fig. 34 LL-G fault on zone-7 using morphing

Fig. 35-fig.40 are the o/p's at zone-7 LL-G faullts using WTT and WMT. Fig.35-fig.37 are the fault indices on zone-7 LL-G

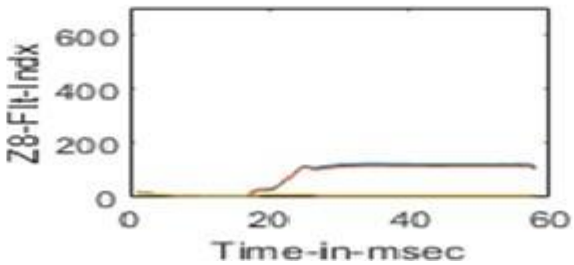

Fig. 35 LL-G fault on zone-7

fault. Observed the o/p's more 1000 fault accuracy, smooth and clarity signals are obtained from WMT. Fig.38-fig.40 are the

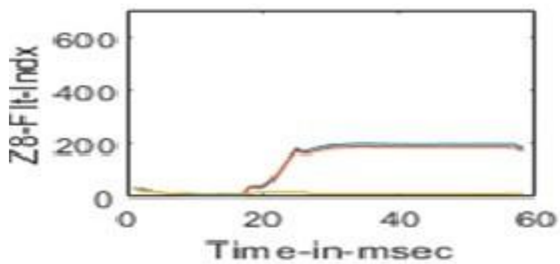

Fig. 36 LL-G fault on zone-7

fault variation on same zone. At every 10km's fault are detected. More fault accuracy occur on WMT. At initial stage fault accuracy will be high and gradually decrease but some upand downs. Fig.41-fig.46 are the L-L fault on zone-8 and its t/m/n line length is 220km. fig.41-fig.43 are the fault indices of L-L fault on zone-8. Observed here more fault accuracy occur at WMT compare to WTT. Fig.44-fig.46 are the L-L fault variation on zone-8, at initially fault accuracy are less and gradually increased when going through the transmission line. Compare to WTT and WMT smooth, clarity and more efficient results are came from WMT Fig.41-fig.46 are the three phase faults on zone-8. Fig.41-fig43 are the fault indices on zone-8 more fault accuracy are observed on WMT compare to WTT. Fig.44-fig.46 are the fault variation on zone-8. Compare to WTT and WMT more clarity, smooth signal and

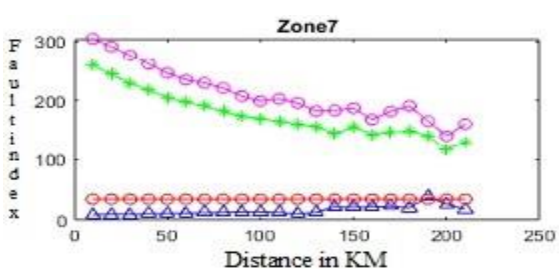

Fig. 37 LL-G varying fault on zone-7 using morphing

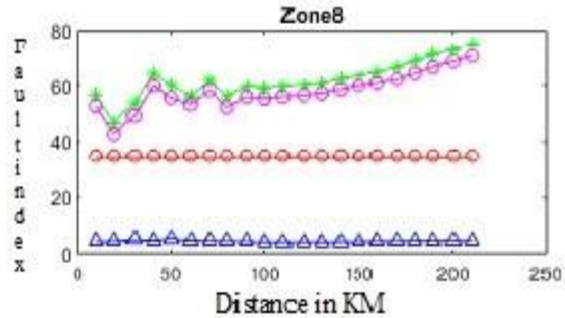

Fig. 38 L-L varying fault on zone-8 using boir2.2

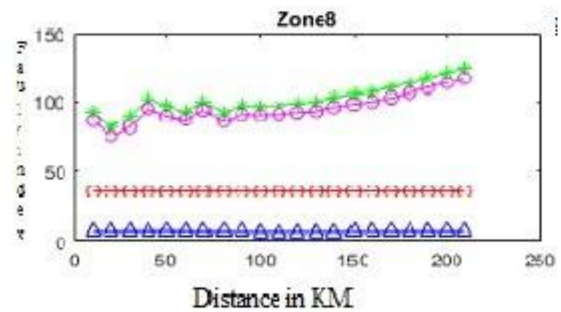

Fig. 39 L-L varying fault on zone-8 using coif1

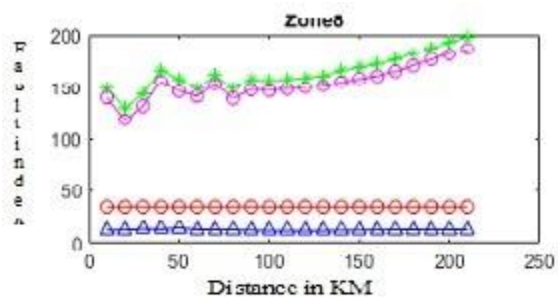

Fig. 40 L-L varyingfault on zone-8 using morphing

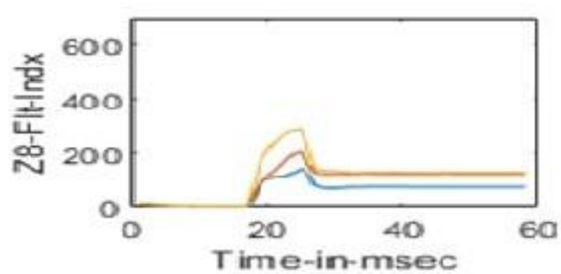

Fig. 41 LLL fault on zone-8 using bior2.2

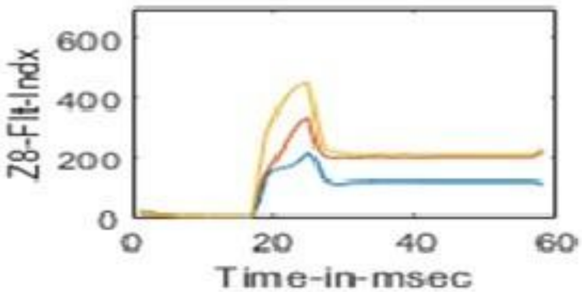

Fig. 42 LLL fault on zone-8 using coif1

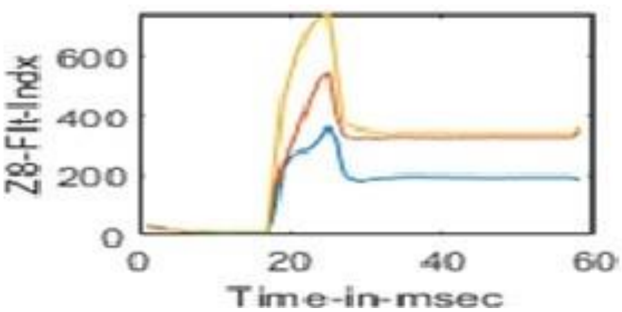

Fig. 43 LLL fault on zone-8 using morphing

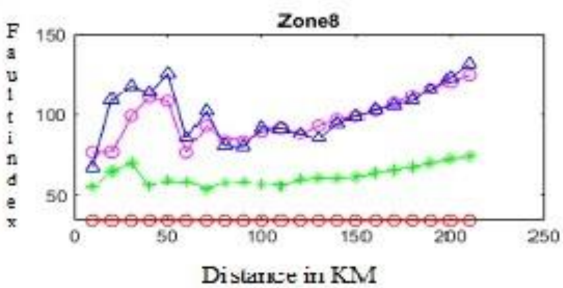

Fig. 44 LLL varying fault on zone-8 using bior2.2

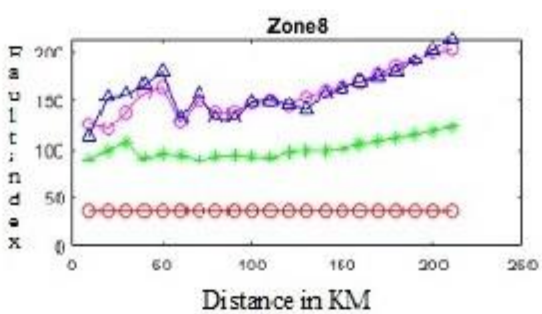

Fig. 45 LLL varying fault on zone-8 using coif1

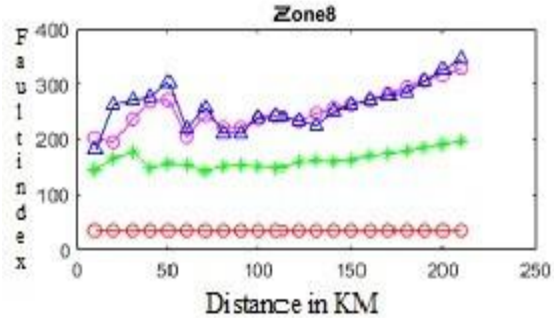

Fig. 46 LLLvaryingfault on zone-8 using morphing

more accuracy and efficient results are obtained from WMT shown in fig.46. In this phase-B phase-C occur more fault compare to phase-A. Below the Th value is a healthy fault and above Th value is unhealthy fault

V. CONCLUSION

With the increasing power demand an uninterrupted power supply is needed The faults occurring on the transmission system have to be detected, categorized and faulty terminal has to be identified within no time. The faults on the transmission system have been detected using WTT and WMT Both these methods were run through MATLAB program using BIORr2.2 and COIEFF programs. All symm etrical and unsymmetrical faults were applied on two 110km and two 220km transmission lines. By comparing all the results more fault accuracy was observed on WMT. And fault detection time period was set at 20ms but fault has been detected before the time-period. For Both WTT and WMT the fault detection and time period were same but more accuracy, smooth signals and exact phase faults were clearly detected through WMT. Fault variations were shown at different distances. Out of all the three phases, the phase which was highly

effected also detected. Swift detection and exact location of fault were possible by using WMT compare to WWT at any terminal and for all type of faults.

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