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High Impedance Fault Detection on Rural Electrical Distribution System

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Abstract— High impedance is difficult to identify through conventional protection such as distance or over current relays. Fault location plays very important role in power system engineering in order to clear fault quickly and restore power supply with minimum interruption. The major faults in distribution lines are line to ground fault, line to line fault and three phase faults. In this paper a 100 km, 11KV, 50 Hz power distribution line model is developed using MATLAB to obtain fault voltage and current waveforms. The fault conditions are simulated using MATLAB-SIMULINK and fault detection is implemented with Daubechies wavelets. During the occurrence of faults, the grid current and voltages undergoes transients. Discrete wavelet transform has been applied as a noble technique for non-stationary signal analysis. These transients can be analyzed using discrete wavelet transform and the fault can be classified. The result shows that the algorithm is capable of performing the fault locations with accuracy.

Index Terms— Power Transmission and distribution, Fault detection, Discrete Wavelet Transform (DWT), Signal Processing.

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1 INTRODUCTION

TO clear fault in power system and restore power supply as soon as possible with minimum interruption fault location and distance estimation is very important issue. For reliable operation of system equipment and satisfaction of customer it is very necessary. Several techniques were applied in the past for estimating fault location such as line impedance based numerical methods, Fourier analysis and travelling wave methods. These methods do not perform time localization of time varying signals with acceptable accuracy. Discrete wavelet Transform method is used in this paper because it is very effective in detecting fault generated signals with varying time .Wavelet Transform has been used extensively for estimating fault location accurately. Wavelet Transform has very important characteristics of analyzing the waveform and time scale rather than in frequency domain. Different types of faults encounters in power system, that faults are classified as single line-to-ground faults, line-to-line faults, double line to ground faults, and three phase faults. Because of these faults power system components are subjected to maximum stresses. These faults give rise to serious damage to power system equipments. During the occurrence of fault, the grid voltage and current undergoes transients. These transients can be analyzed using discrete wavelet transform and the fault can be classified.Fault not only effects power system equipments but also power quality. So it is necessary to detect the fault and fault location and separate faulty section from distribution line. Fig 1 shows the proposed system of discrete wavelet transform based distribution line fault.

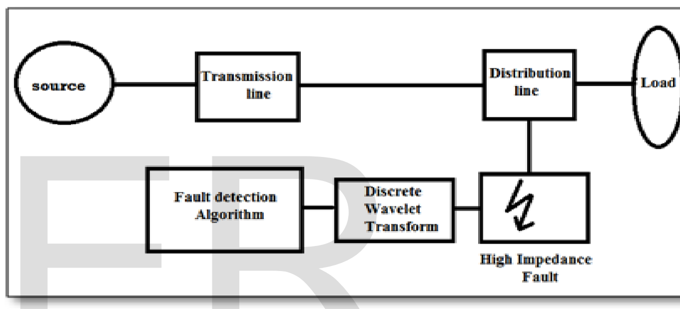

fig1. Proposed system of discrete wavelet transform based distribution line fault

2 DISCRETE WAVELET TRANSFORM

Wavelet Transform is the signal processing procedure and has been widely used for signal processing purpose. Wavelet is more influential than conventional method. The Wavelet Transform is suited to wide band signals and may contain both sinusoidal and non sinusoidal components. This is suitable to the ability of wavelets focus on short time intervals for high frequency components.DWT analyses the signals at different frequency bands with different resolutions. DWT uses filters of different cut-off frequencies to examine the signal at different scales. The DWT is simpler to implement than Continuous Wavelet Transform because CWT is to be computed by varying the scale of the analysis window, shifting the window in time and multiplying the signal . Fourier techniques cannot achieve good detection in both time and frequency for a transient signal. The DFT has some disadvantages over the DWT. The main advantage of WT over Fourier Transform is that the size of analysis window varies in quantity to the frequency analysis. Hence WT can offer a superior method in terms of localization and detection. Such wavelet components appear to be helpful for detecting, localizing, and classifying the sources of transients. Hence, the wavelet transform is feasible and practical for analyzing power system transients.

Distribution Line equations:

When high impedance fault occurs on distribution line the fault current decreases and voltage at fault point decreases. The instantaneous voltage $u(x,t)$ and current $i(x,t)$

$$d\varphi(t)=u(x,t)Cdx \qquad (1)$$

$$d\varphi(t)=i(x,t)Ldx \qquad (2)$$

Calculating the voltage drop in the positive direction of x of the distance dx one obtains

$$u(x,t)-u(x+dx,t)=-du(x,t)=\frac{-du(x,t)}{dx}dx=(R+L\frac{d}{dt})i(x,t)dx \qquad (3)$$

If dx is cancelled from both sides of equation (3), the voltage equation becomes

$$\frac{du(x,t)}{dx}=-L\frac{di(x,t)}{dt}-Ri(x,t) \qquad (4)$$

Similarly, for the current flowing through G and the current charging C, Kirchhoff's current law can be applied as

$$i(x,t)-i(x+dx,t)=-di(x,t)=\frac{-di(x,t)}{dx}dx=(G+C\frac{d}{dt})u(x,t)dx \qquad (5)$$

If dx is cancelled from both sides of equation (5), the current equation becomes

$$\frac{di(x,t)}{dx}=-L\frac{du(x,t)}{dt}-Ru(x,t) \qquad (6)$$

For evaluating the performance of the proposed algorithm, the authors adopt MATLAB/Simulink for fault data generation and algorithm implementation, which is a 11Kv, 50Hz, Transmission Line Length: 100 Km, pi section.

3 SIMULATIONS

3.1 Simulation System

In this paper fault location was performed on power system model which is shown in figure 2. The simulation was performed using MATLAB/ SIMULINK.

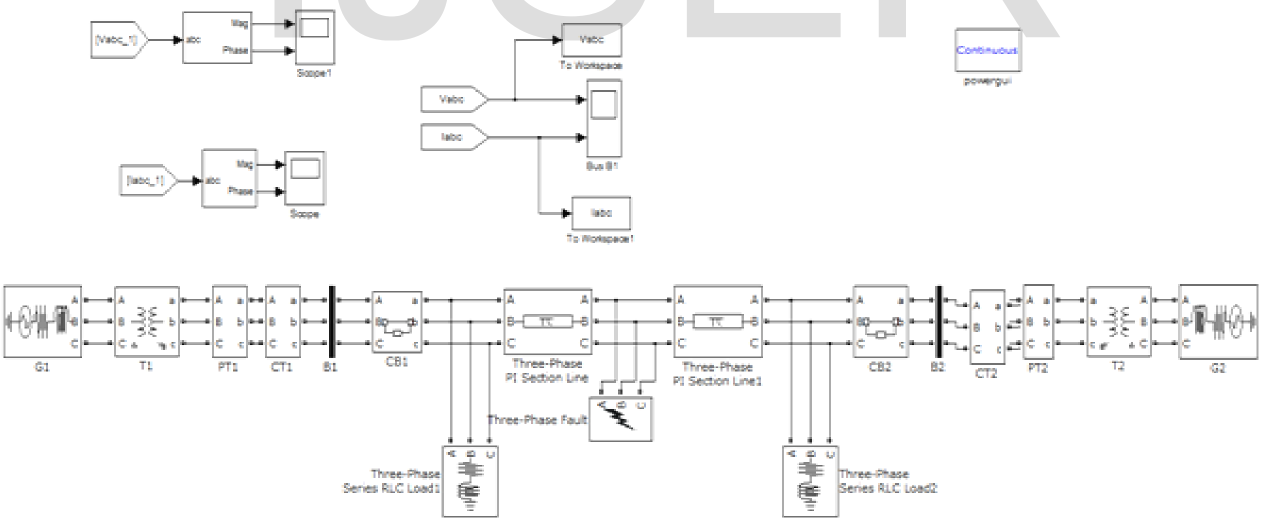

Fig2. Simulink Distribution line model

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Simulation Results

Fault types under consideration, namely: single phase to ground (SLG: AG, BG, CG), line to line (L-L: AB, BC, CA), double line to ground (ABG, BCG, ACG) and three-phase fault (3-P: ABC).

1] Fault Type: AG Fault

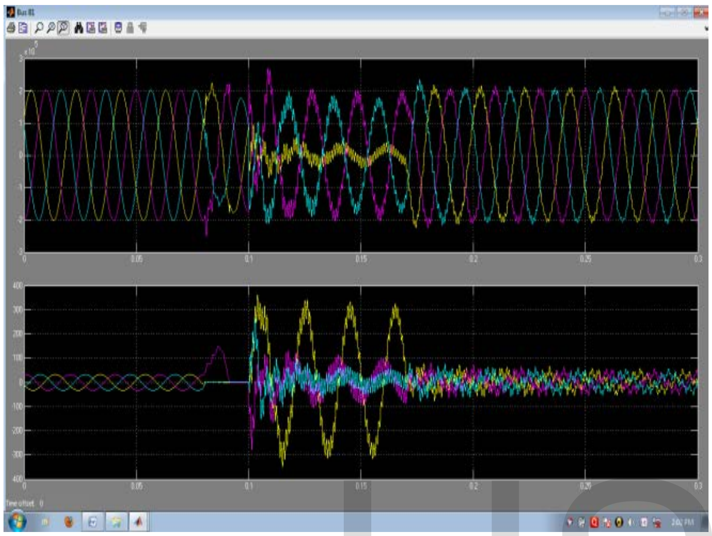

Fig3. Voltage and current waveform of AG fault

2] Fault Type: BG Fault

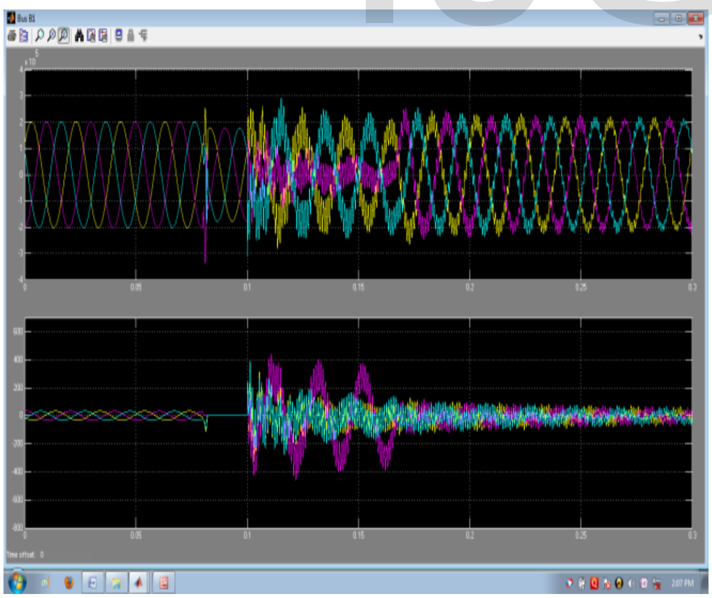

Fig4. Voltage and current waveform of BG fault

3] Fault Type: CG Fault

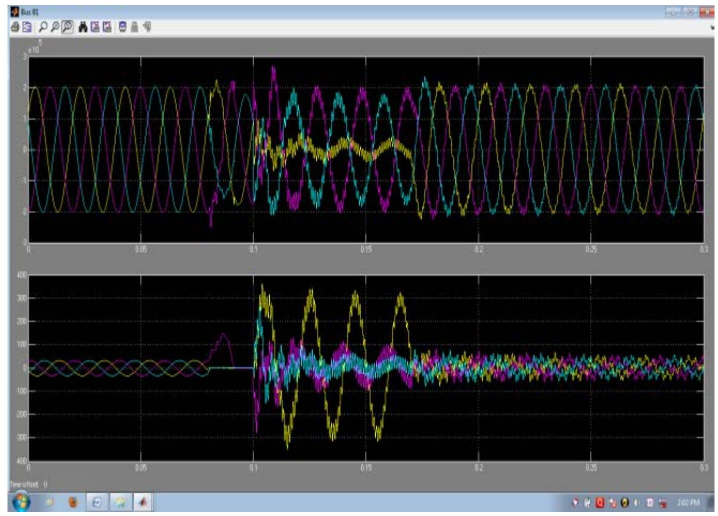

Fig5. Voltage and current waveform of CG fault

4] Fault Type: AB Fault

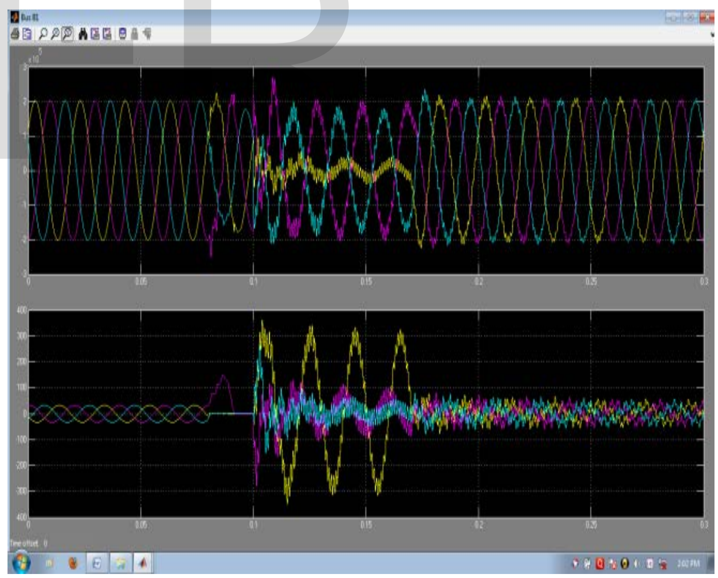

Fig6. Voltage and Current waveform of AB fault

5] Fault Type: BC Fault

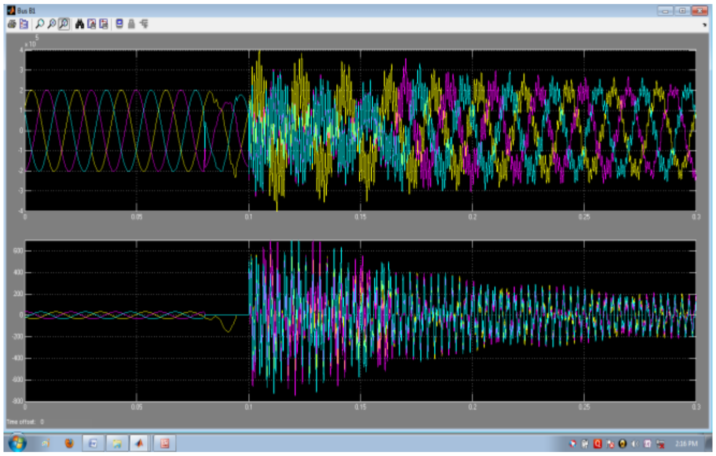

Fig7. Voltage and Current waveform of BC fault

6] Fault Type: AC Fault

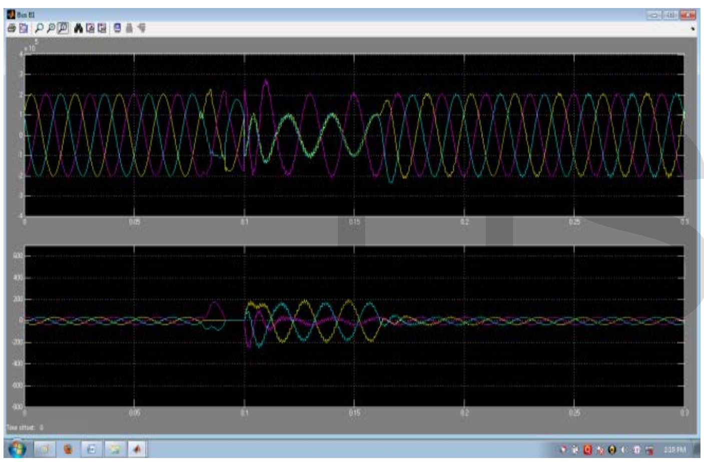

Fig8. Voltage and Current waveform of AC fault

7] Fault Type: ABG Fault

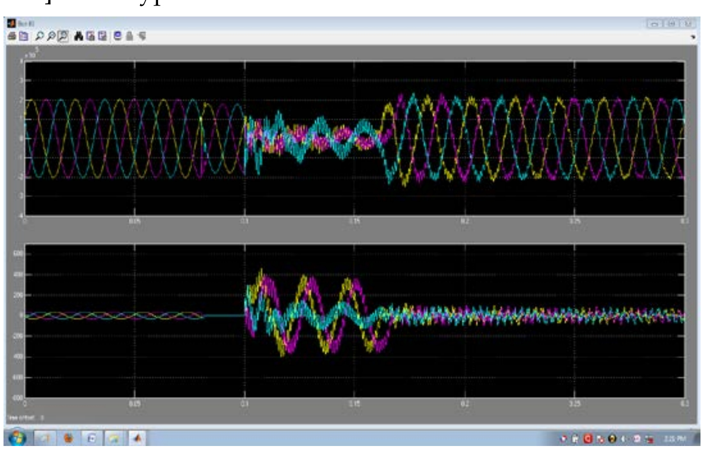

Fig9. Voltage and Current waveform of ABG fault

8] Fault Type: BCG Fault

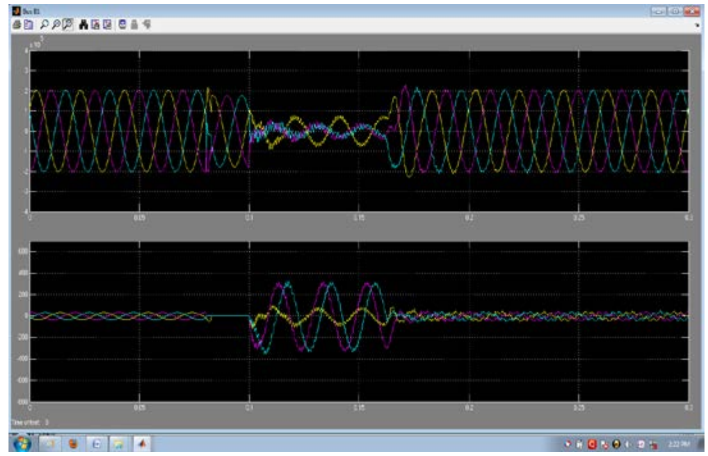

Fig10. Voltage and Current waveform of BCG fault

9] Fault Type: ACG Fault

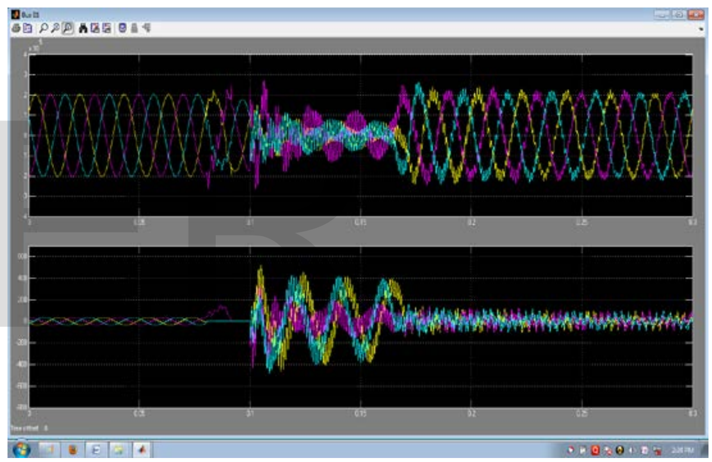

Figure 11: Voltage and Current waveform of AC**G** fault

Table 1: Voltage and current values of LG fault

	AG	BG	CG
VA	2v10^5 V	2v10^5 V	2v10^5 V
VB	2x10^5 V	1x10^5 V	2x10^5 V
VC	0.5x10^5 V	2x10^5 V	1x10^5 V
IA	100 A	120A	200A
IB	100 A	350A	200A
IC	300 A	120A	400A

TABLE 2: VOLTAGE AND CURRENT VALUESOF LL FAULT

	AB	BC	AC
VA	1v10^5 V	3v10^5 V	1v10^5 V
VB	1x10^5 V	2x10^5 V	2x10^5 V
VC	2x10^5 V	2x10^5 V	1x10^5 V
IA	200 A	400A	150A
IB	200 A	500A	40A
IC	50 A	500A	150A

TABLE 3: VOLTAGE AND CURRENT VALUES OF LLG FAULT

	AB	BC	AC
VA	0.7v10^5 V	0.7v10^5 V	0.8v10^5 V
VB	0.7x10^5 V	0.5x10^5 V	1.5x10^5 V
VC	1x10^5 V	0.5x10^5 V	0.8x10^5 V
IA	400 A	100A	400A
IB	400 A	300A	200A
IC	100 A	300A	400A

4 DISCUSSION OF THE RESULTS

The results are presented in figures 3 to 9 shows the Voltage and Current waveforms of Fault types under consideration: single phase to ground (SLG: AG, BG,CG), line to line (L-L: AB, BC, CA), double line to ground (ABG, BCG, ACG).We extract the Wavelet feature from output waveform, and then compare these features with our database. If distance is below the threshold value then we find the index of that features. In above waveforms fault time is 0.08 to 0.16 secs and SL-G, L-L and LLG fault has been detected. The total simulation time of above faults is 0.3 secs. The Voltage and Current values are recorded from the work space environment of the SIMULINK which has presented in tables 1, 2 and 3.

Pro

5 CONCLUSION

The application of the wavelet transform to estimate the fault detection on distribution line has been investigated. The fault resistance in the fault increases per error increases. The most suitable wavelet family has been made to identify the fault on distribution line. It was found that better result was achieved using Daubechies 'db5' wavelet with an error of 3%. Simulation of single line to ground fault (S-L-G) for 11kv, 100km transmission line was performed using SIMULINK. The waveforms obtained from SIMULINK have been converted as a MATLAB file for feature extraction. Tests including Phase to ground faults and phase to phase faults and double phase to ground faults simulation results show this DWT method. DWT has been used to analyze the signal to obtain the coefficients for detecting the fault. Finally it was shown that the proposed method is accurate enough to be used in detection of distribution line fault location.

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Appendix

System Parameters

1. Transformer:
   Winding 1- v1=11kv ,R1= 0.002904Ω,L1=0.00036975 H
   Winding 2-v2=220kv, R2=0.32Ω ,L2=0.40744 H
2. Circuit Breaker
   Transition time (s) 0.08 to 0.16 secs
   Breaker resistance 0.001 ohm
3. Transmission Line:

TABLE : TRANSMISSION LINE PARAMETER

+ve and zero sequence resistance (ohms/km)	+ve and zero sequence inductance (H/km)	+ve and zero sequence Capacitance(F/km)
0.01237,0.03864	0.9337*10-3,4.1264*10-3	12.74*10-9,7.751*10-9