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A Novel Method to Detect Faults in Transmission Lines

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***ABSTRACT*:**
The demand of electricity or power increases day-by-day. It may cause increasing the transmission line capacity from one place to the other place. But during the transmission some faults occur in the system, such as L-L fault (line to line), 1L-G fault (single line to ground), 2L-G fault (double line to ground) etc., therefore Transmission line protection is an important issue in power system. These faults affect the power system equipment which is connected to system. The main aim of this work is to study various types of faults and also identifies the effect of the fault in transmission line by using WAVELET TRANSFORMS. The simulation is developed in MATLAB and the transmission line model is designed. MATLAB software is used to simulate different fault conditions on high-voltage transmission line. The voltage and current signals are retrieved and they are processed through wavelet transform to identify faults clearly.
KEYWORDS: Wavelet transform, negative sequence components, line to ground fault, line to line fault

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I. INTRODUCTION

An electric power system with multiple sources and loads allows the transfer of electricity from network power plants to consumers. Complexity is increasing in all areas of the electrical system. Therefore, for reliable operation of power system networks, it is important to accurately identify the type and location of the fault. The faults in power system are line to ground faults (LG faults), line to line faults (LL Faults), double line to ground fault (LL –G fault) and three phase faults. The most frequently occurring faults in any power system network are line to ground (LG) and line to Line (LL) faults. A lot of research is being done in the field of fault detection in power system networks.

A novel selectivity technique is proposed by [1] to detect the fault feeder in MV networks using the directionality of DWT detail coefficient of a residual current of each feeder. For identification of fault locations in double circuit lines, power system transients are analyzed by wave let transform [2]. Independent component analysis is proposed for fault detection of faulty negative sequence current in series compensated lines [3]. A wavelet conversion-based method of measuring the time and frequency of high frequency transients caused by faults in transmission lines has been proposed with the intention of finding the fault point [4]. In [5] authors proposed a method of analysis of faults with different load conditions for classification, localization and detection of faults in transmission lines. In [7] and [8] authors proposed novel technique for fault detection in high voltage transmission line using the wavelet transform during power swing condition. The power system protection engineer has been challenged with the detection of High Impedance faults from the beginning of power distribution. In [9] authors address the variations in the system voltages and load currents during the faulty conditions with linear and non-linear loads. In [10] authors reports a study on fault analysis on high voltage transmission line between Barapukuria and Bibiyana in Bangladesh. PSCAD simulation tool is used to study both 400 kV single circuit and 400-230 kV double circuit transmission line.

In this paper the study of general types of the faults (e.g. balanced and unbalanced faults) occurred in the transmission line of the power system. MATLAB simulations of the transmission line are carried out and faults are created. Then detection of these faults is done by using wavelet transforms.

II. NEGATIVE SEQUENCE COMPONENT OF VOLTAGE AND CURRENT SIGNALS

Negative sequence component is one of the key indicators which quantify the presence of any disturbances in the voltage and current signals. Thus, in this technique, the negative sequence component of the voltage and current signals is considered for analysis towards effective detection of different faults. The negative sequence component of voltage and current can be expressed by symmetrical component analysis as:

$$V_n = \frac{1}{3}(V_a + a^2V_b + aV_c)$$
$$I_n = \frac{1}{3}(I_a + a^2I_b + aI_c)$$

Where V_a, V_b, V_c are three phase voltages , and I_a, I_b, I_c are three phase currents and $a = 1\angle 120^0$, is the complex operator. The negative sequence component of the extracted voltage and current signals is obtained by passing it through the three-phase sequence analyzer block in MATLAB/Simulink. Out of the three sequential components, it is only negative sequence component of the voltage signal, considered in this study because it reflects the information under disturbance condition. Quantification of the negative-sequence voltage at the target location is carried out which provides high degree of immunity to noise, for detection of fault event and other disturbances thus enable better performance.

III. WAVELET TRANSFORM

The wavelet transform decomposes transients into a series of wavelet components, each of which corresponds to a time domain signal that covers a specific frequency band containing more detailed information. Wavelets localize the information in the time–frequency plane which is suitable for the analysis of non stationary signals. WT divides up data, functions into different frequency components, and then studies each component with a resolution matched to its scale. In this study, the voltage and current signals are used as the input signals of the wavelet analysis. Daubechies4 (dB4) mother wavelet, is employed since it has been demonstrated to perform well. The islanding of the study cases is detected through discrete wavelet transform (DWT). Both approximation and details information related fault voltages are extracted from the original signal. When the utility grid isolates, it can be seen that variations within the decomposition coefficient of the voltage and current signals contain useful signatures. Filters of different cut-off frequencies are used to analyze the signal at different scales. The signal is passed through a series of high pass filters to analyze the high frequencies, and it is passed through a series of low pass filters to analyze the low frequencies. Hence the signal (S) is decomposed into two types of components approximation (C) and detail (D). The approximation (C) is the high scale, low-frequency component of the signal. The detail (D) is the low-scale, high-frequency components. The decomposition process can be iterated, with successive approximations being decomposed in turn, so that one signal is divided into many lower resolution components which is called the wavelet decomposition. As decompositions are done on higher levels, lower frequency components are filtered out progressively.

IV. SIMULATION MODEL

The simulation model for fault analysis is shown in Figure 1. In the simulation model the first block represents a three phase equivalent source. The block for voltage and current measurement captures all the voltages as well as currents during the simulation. The two blocks representing distribution line. Between the line blocks, different types of faults are created. The last block represents a 3 phase load consisting of resistance and inductance, and non linear load. Figure 1 shows the Simulation Model for Three Phase Transmission Line Fault Analysis. And figure 2 shows Subsystem model to analyze the negative sequence components at all the buses. Various faults are created in the line in MATLAB simulink and these faults are identified using wavelet transform. In order to study and analyze the transmission line fault two three phase sources of rating 100MVA, 13.8KV, 50Hz are connected. These two sources are connected to two transformers of rating1000MVA, 13.8/500KV and 1000MVA, 500/13.8KV. Also the resistive load is connected at bus 3, and faults are created at 0.2 seconds. Also, three transmission lines are used in which one is of 100Km long and another two transmission lines having distance 50Km.

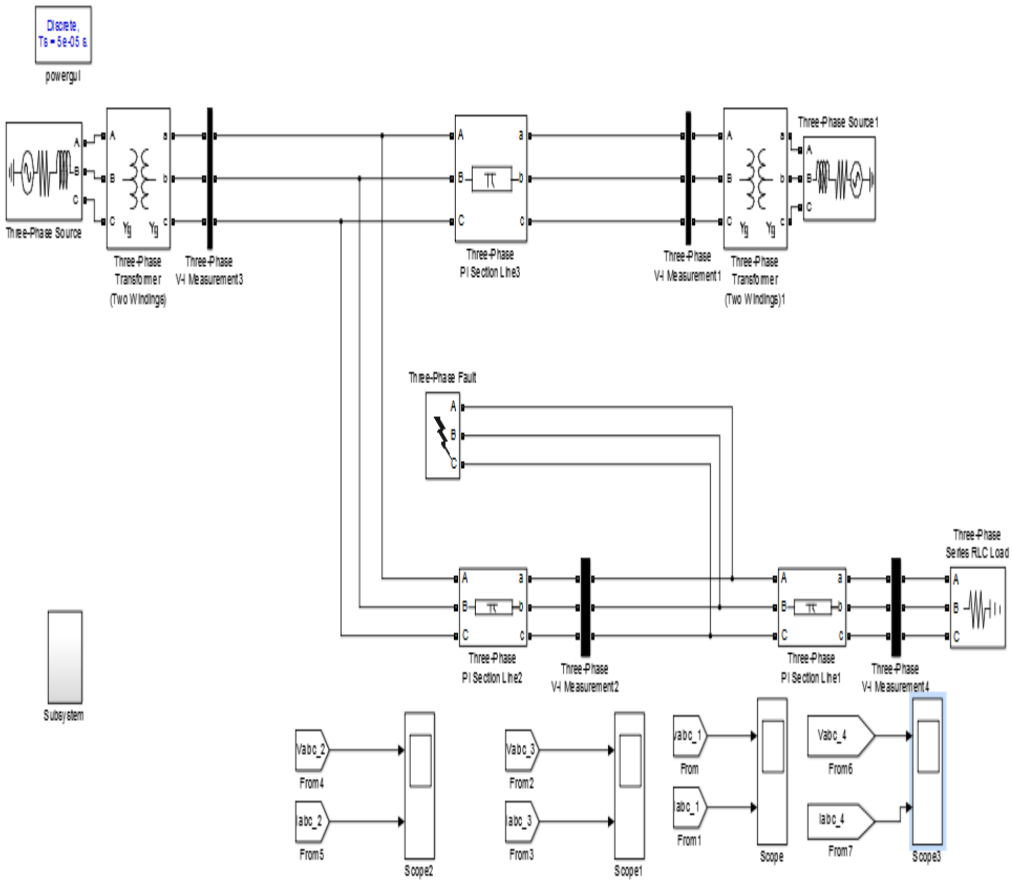

Figure 1: Simulation Model for Three Phase Transmission Line Fault Analysis

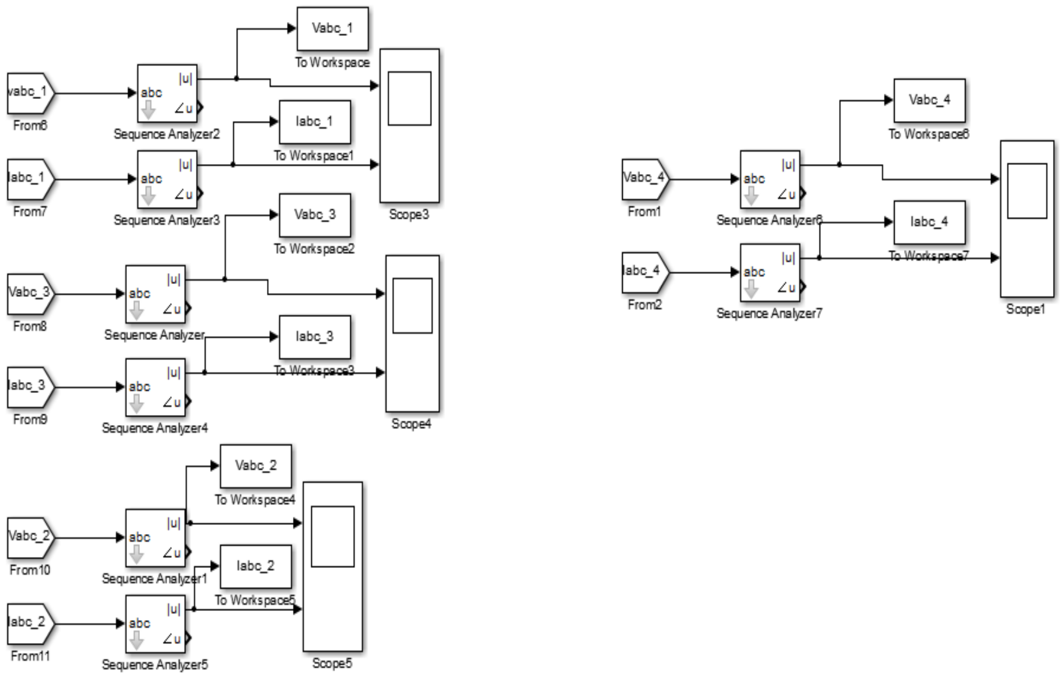

Figure 2: Subsystem model to analyze the negative sequence components at all the buses.

V. SIMULATION RESULTS

The model is simulated and the voltage and current signals are retrieved. The fault is created at 0.2 sec. The complete simulation is carried out using MATLAB-SIMULINK software package. The negative sequence voltage and currents are processed through Wavelet Transform (db4) for fault detection. The d1 coefficients of voltage and current signals at all fault conditions are shown in following figures. The d1 coefficients clearly identify the various fault conditions. Figure 1 shows three phase voltage and current signals at no fault condition i.e. at normal condition.

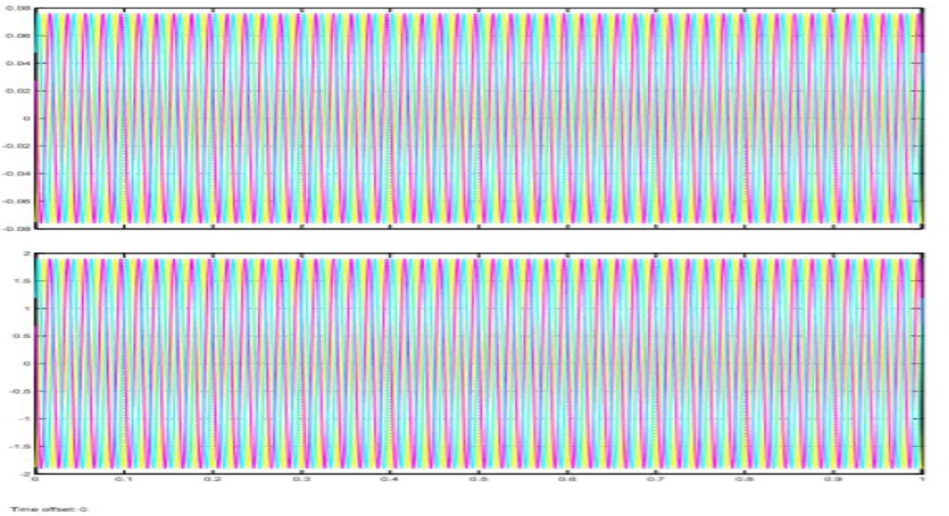

Fig 3 Three phase voltage and current signals at no fault condition

Figure 4 shows the voltage and current signals for single line to ground (LG) fault. And the corresponding d1 coefficients of LG fault is shown in figure 5.

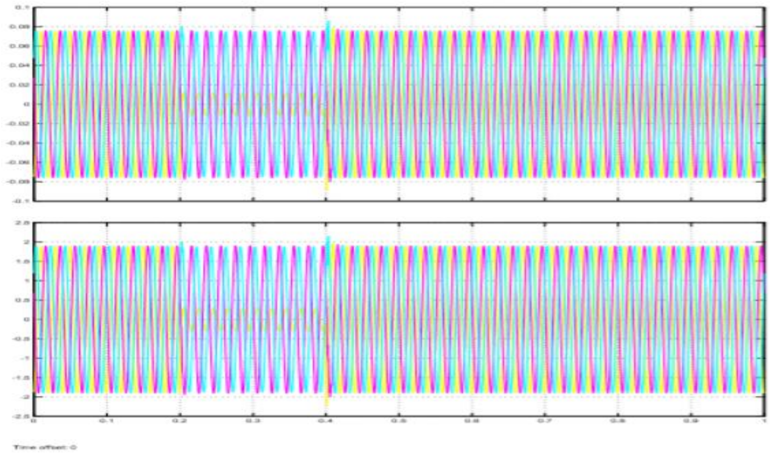

Figure 4: Voltage and current signals for line to ground fault.

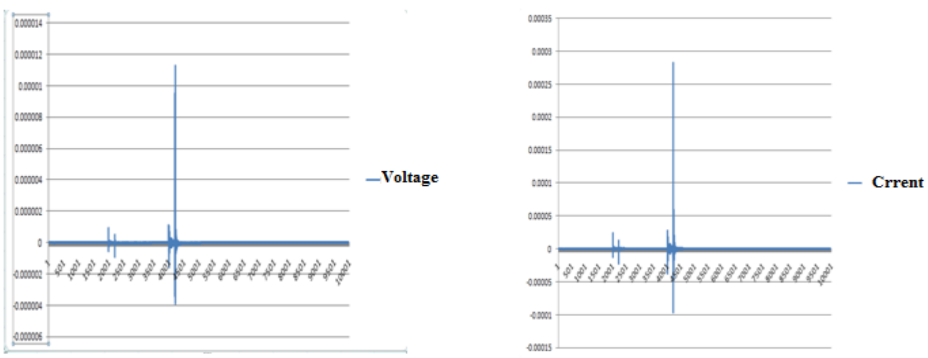

Figure 5: d1 coefficients of voltage and current signals for line to ground fault

Figure 6 shows the voltage and current signals for line to line (LL) fault. And the corresponding d1 coefficients of LL fault is shown in figure 7.

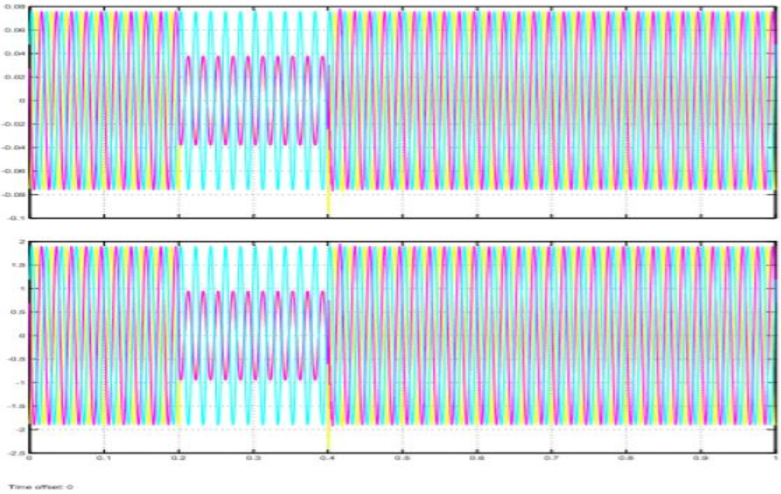

Figure 6: Voltage and current signals for line to line fault.

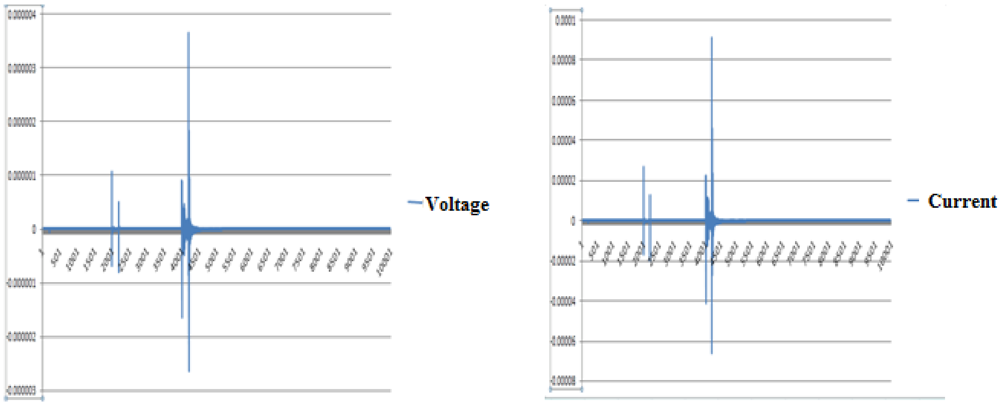

Figure 7: d1 coefficients of voltage and current signals for line to line fault

Figure 8 shows the voltage and current signals for double line to ground (LL-G) fault. And the corresponding d1 coefficients of LL-G fault are shown in figure 9.

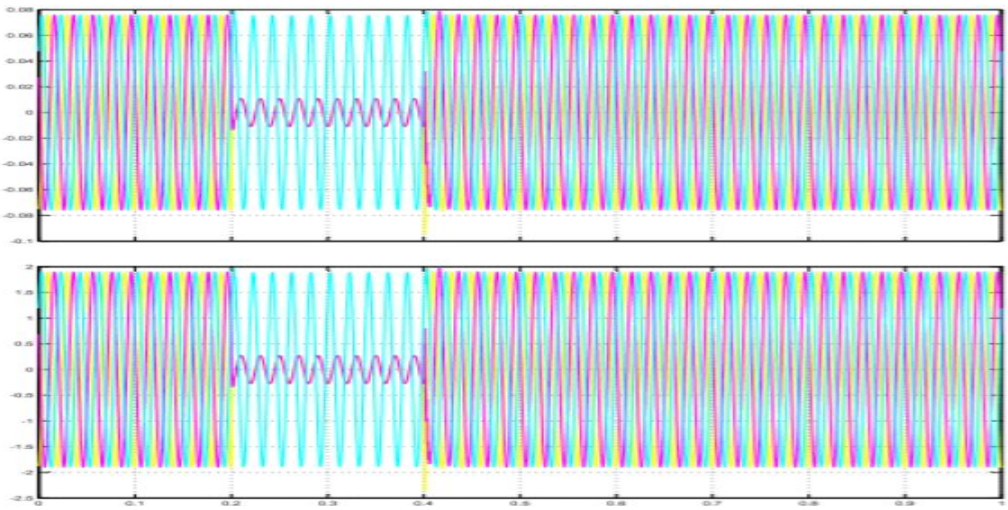

Figure 8: Voltage and current signals for double line to ground fault.

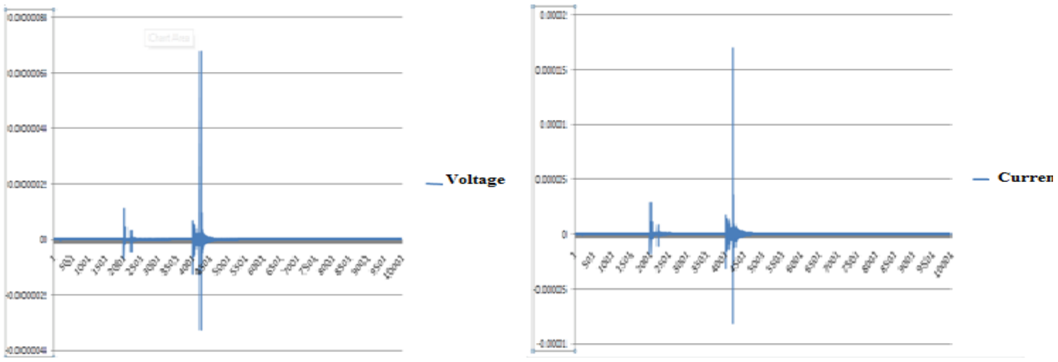

Figure 9: d1 coefficients of voltage and current signals for double line to ground fault

Figure 10 shows the three phase voltage and current signals for triple line (LLL) fault or three phase fault. And the corresponding d1 coefficients of LLL fault are shown in figure 11.

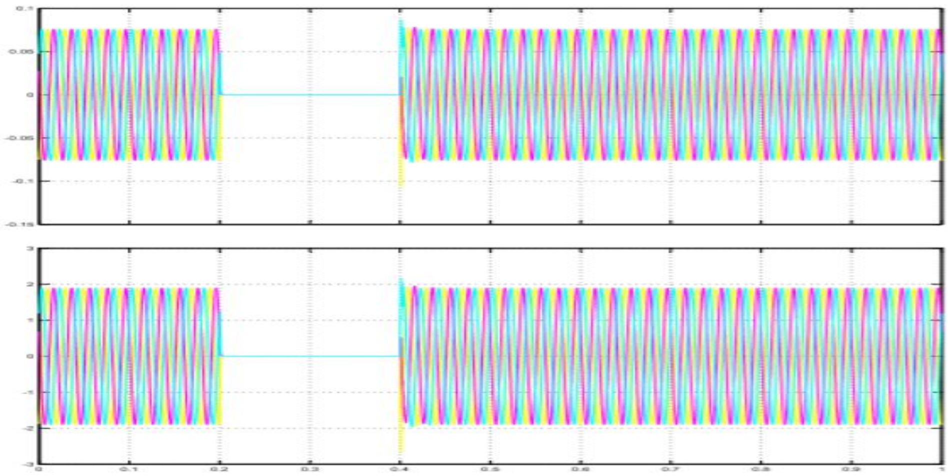
Figure 10: Voltage and current signals for triple line fault.

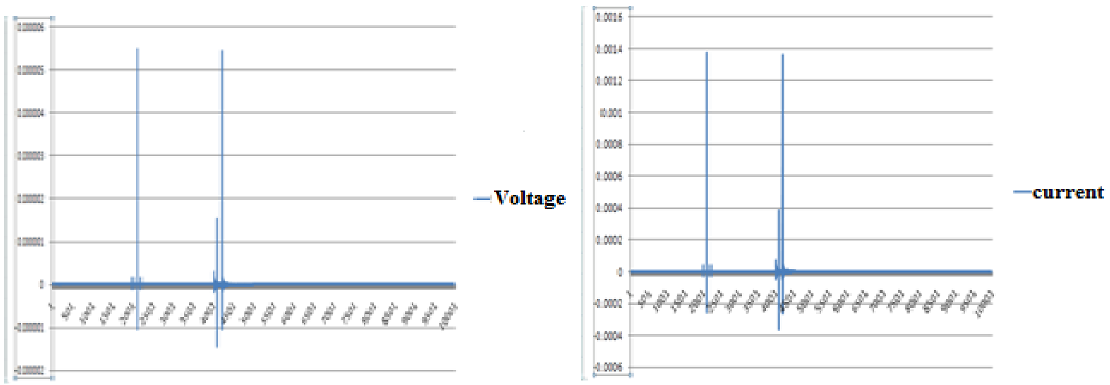

Figure 11: d1 coefficients of voltage and current signals for triple line fault

Figure 12 shows the three phase voltage and current signals for triple line to ground (LLL-G) or three phases to ground fault. And the corresponding d1 coefficients of LLL-G fault are shown in figure 13.

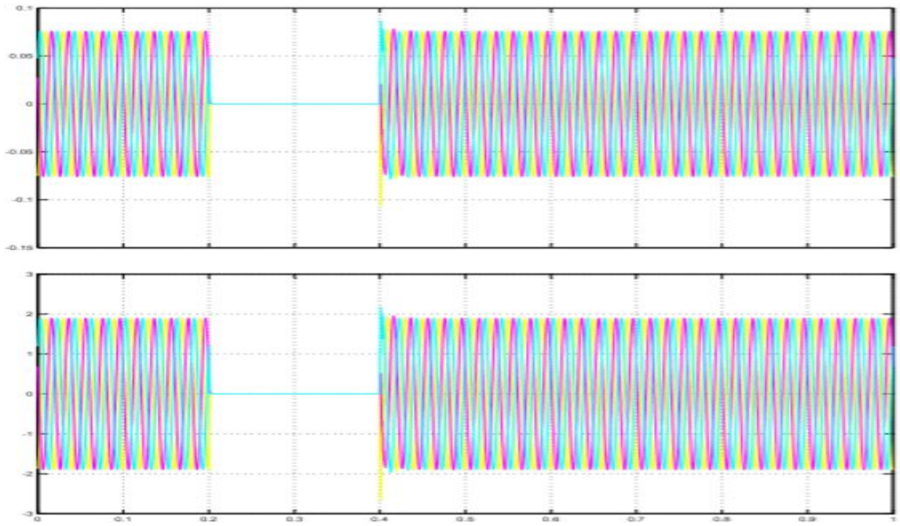

Figure 12: Voltage and current signals for triple line to ground fault.

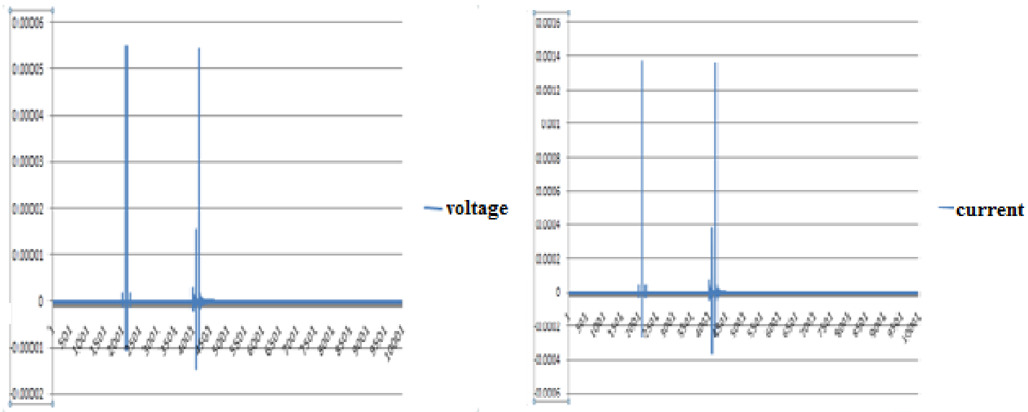

Figure 13: d1 coefficients of voltage and current signals for triple line to ground fault

VI. CONCLUSION

The proposed technique investigates the negative sequence component of voltage, current for fault detection in transmission system. Wavelet transform is used to process the negative sequence voltage and current signals and the d1 coefficients clearly detect the fault conditions. And it clearly discriminate different types of faults that are occur in the transmission system such as line to ground fault, double line fault, double line to ground fault, triple line fault and triple line to ground fault. Thus the proposed method is highly effective for fault detection.

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