MULTI-RESOLUTION ANALYSIS BASED DISTANCE PROTECTION OF TRANSMISSION LINE

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ABSTRACT

Electrical transmission lines are prone to faults and failures. When a fault occurs, it is impossible most of the times to fix it manually. Extra High Voltage (EHV) transmission lines are designed to transfer large amount of power from one location to another. The length exposed to the environment is a major reason for occurrence of faults on the lines. A fault on a high voltage transmission line affects the stability of the overall power system, which sometimes leads to permanent damage of the equipment. Relays are developed and installed to protect the lines. The transmission line protection relays, in the industry, are based on the fundamental frequency components of the voltages and currents. These relays need at least one fundamental frequency cycle for performing the protection operation. Voltage and current traveling waves are generated when a fault occurs on the transmission line. The velocity of propagation of traveling waves is finite and the level of the waves decreases with increase in the distance traveled. Information about the fault can be obtained by analyzing the traveling waves. This dissertation report present, the transmission line protection system using wavelet multi-resolution analysis. The faulted current and voltage signal get transfer into multi-resolution analysis the after analysis this transfer to threshold based system. That threshold system operates the circuit breakers connected at the each end of transmission line by sending trip signal during abnormal faulted condition occurs. An improved simulation software using MATLAB was developed to study the proposed fault diagnosis techniques. Comprehensive performance studies were implemented and the test results validated the enhanced performance of the proposed approach over the traditional fault diagnosis performed by the transmission line distance relay.

Keyword: - *Extra high voltage transmission line, multi-resolution analysis, second order harmonics, threshold.*

1. INTRODUCTION

To spread power from generating stations to remote load centers, transmission lines are used. Due to lightening, miss-operation, overload, short circuits, human errors, faulty equipment's and aging, faults may occur on these lines. When fault occurs, the faulted phase voltage decreases and huge currents will flow which can burn out the components if not interrupted quickly.

Either insulation failure or failures of conducting path are the major causes for the occurrence of faults. In addition to this, faults are also caused due to over voltages which are occurring due to switching surges and lightening. Falling of conducting objects on overhead lines, encounter of flying birds, tree branches, direct lightening strokes, ice loading, creepers, storms etc. are the other reasons which can cause faults in overhead lines. Moisture in the soil, heat of earth, ageing of cables may lead to the solid insulation failure in cables, transformers and generators [1]. There are two types of faults: Symmetrical faults, and asymmetrical faults. Table 1 shows the types of faults.

Table 1:- Types of faults

Types of fault	Symbol	% Occurrence	Severity
Line to Ground	LG	75-80%	Very less
Line to Line	LL	10-15%	Less
Double Line to Ground	LLG	5-10%	Less
Three phase	LLLG/LLL	2-5%	More

There are several ill effects caused by a fault in a power system. Severe short circuit current may occur in the system due to fault which may prove fatal to the several equipment's of the power system and lead to the overheating of the system. Heavy current is also the reason behind the setting up of very high mechanical stresses. Failure of industrial loads, due to drop in the voltage of healthy feeders. Heating of rotating machines may occur due to unbalancing of currents and supply voltages arising due to short circuit. Loss in system stability. Continuity of power supply is adversely affected. Just as transmission lines vary widely in their characteristics and configurations, so too do their protection schemes. Several fundamental factors influence the choice of protection schemes applied to a given line. Type of line: overhead, cable, line length, single line, parallel line, radial, two-ended, three-ended, etc. Line function and importance effect on service continuity and timing requirement for isolation from the system. Coordination and compatibility with associated lines and systems. Most high-voltage transmission lines are protected by distance relays. Compared to over-current relays, distance relays are inherently directional, less susceptible to source impedance variations, and have higher load ability limits.

The three most commonly used communication assisted distance protection schemes in the industry are Direct Under-reaching Transfer Trip (DUTT), Permissive Overreaching Transfer Trip (POTT), and Directional Comparison Blocking (DCB).DUTT has the advantages of minimal susceptibility to power system swings. DUTT has the disadvantage of dependency on communication channels for faults external to overlapping coverage regions. The POTT scheme has the advantage of being more secure, as it requires permission from the remote relays to trip, and it can provide higher-speed tripping. It has the disadvantage of being dependent upon the communication channel time for all line faults. The DCB is the most trip dependable, because its operation is not dependent on the communication channel or operation of the remote relays. It is the least secure in that a loss of communication can result in line trips for faults not on the line. Generally, a complimentary use of high-speed schemes is used for the protection of most 200 kV and above transmission lines.

Transient's current is important and common characteristics which are used to demonstrate the event of fault and switching. Increase in un-expectable operation of power system goes to need have maintained power quality. Relay protection required faster response for this undesired operation is not acceptable because it takes more time. for this we required a sensitive relay system, but sometimes this sensitivity tends to the undesired operation when there is no fault hence people have to face the blackout .hence by finding all these condition of undesired operation of relay and research on them and need of study of fault and switching action. During the starting the motor or transformer at a time in power system, or several motors are start at a same time in agriculture. When power is on .motor get start. Now current taken by motor is high at start, and these starting current produced un-expectable operation. Starting current has more and larger second order harmonics than fault conditions. Hence easy to capture these readings but sometimes starting and fault have a same second order harmonics and hence it is hard to differentiate it. For this research is required. Many algorithms are used in power system but DFT algorithm is popular in digital filtering used in relay operation. But this is used to work on stable current to find out the DC offset component as well as harmonics and accurate output. But this DFT algorithm can't give accurate output in case of real time operation. Some paper presents the increased used window length to overcome this problem. But it increased the operation time and hence delay is occurred.

2. RELATED WORK

In [1] the voltage and current signals at relay location using wavelet filter bank are decomposed. Fault can be detected and for this distance protection relaying and wavelets are used. Impedances can be calculated at relay location at beginning and 50 km from relay location for single line to ground fault. Wavelet transformation is able to detect the fault as well as estimates the phases at relay location and also successfully classify the every type of fault at any distance various types of faults on transmission line accurately classified within one cycle .Because

decomposing is takes place in both time and frequency bands .More study and development on testing the relay for high resistive ground faults gives accurate results.

Author presents that from this Fourier and Walsh transform includes Cosine and Sine-cosine filter. Filtered input is required in wavelet transform. Because it must estimates fast and accurate electrical distance to fault. Power system contains more level of corrupted or distorted signals. Hence area of interest for research is filtering algorithm .hence proposed method provide real information about filter transients behavior of wide range of noise. From this paper we find that, when current signals presents DC offset and also contains high frequency damped oscillation. Sine-cosine filter exhibits the best response but Cosine filter provides slightly better performance than sine-cosine filter. Digital distance relay required low pass anti-aliasing filtering, parameters estimation digital filtering and tripping decision post processing [2] Time varying nature of fundamental frequency and harmonic component in frequency are significantly contributes to high impedance fault .The ratio of third harmonic component is approx. to unity .also phase angle of faulty phase 'A' is zero. where -120 and 120 degree phase angle of phase 'B','C' respectively. The change in low order odd harmonics and their rate of change are significantly contributes to high impedances fault detection .Hence the low order harmonics are less affected by load changes and changes dramatically during high impedances fault condition. Odd harmonics are useful and definite and hence odd harmonics is one of the features of high impedances fault [3]. The wavelet transform provide electromagnetic transients during faults in power system or switching of power system. Frequency domain is useful for investigating source of transient wavelet transform have ability to decompose signal into frequency component. This scheme gives source of transients. We find that , the property of multi-resolution provide easy and accurate and fast location of fault transient as well as provide information about fundamental frequency and its low order harmonic. This capability can be used in design of automated transient classification system.[4] author presents electromagnetic transient program which solve the high impedances fault and capacitor switching operation problem. Wave filter bank differentiate the high impedances and from normal event in distribution system such as capacitor bank switching. High pass filter is input signal and provide behavior of transient signal. Output of low pass filter smoothen the approximation of input signal. Wavelet analysis filter bank (WAFB) is identifying high impedance fault. WAFB is differentiating switching and fault detection .WAFB analyzed

the information in two different frequency range component and these can be performed in just two cycle. in future it will be fast and accurate identification. In [5] author presents that multi-resolution is useful to carry out information of image contain. This is computed with the help of pyramidal algorithm based on quadrature mirror filter. Hence wavelets are used to differentiate several spatial orientation of image. The representation is followed by decomposing the original signal using wavelet for the set of independent frequency channel having a spatial orientation tuning. Here pyramidal algorithm is used which is based on quadrature mirror filter convolution for decomposition and reconstruction of original signal. Wavelets are particularly used to analyzed fractal properties of image. A wavelet representation is lies between spatial and Fourier domain. [6] Author presents the technique used absolute sum value of coefficient in multi resolution signals decomposition taken due to discrete wavelet transform. High impedance faults are detected by using fault indicator and fault criteria. To differentiate HIF and non-fault condition like switching concept this paper is proposed. DWT has advantages that robust to variation in different system and fault condition. DWT has inherent attributes of differentiate between faulty phase and healthy phase .It is useful in transmission line where single pole tripping is employed [7]. It required just current transformer because this technique is based on current signals .And mother wavelet is choose after a long study series wavelet are work on different samples of fault condition and non-fault condition.

In order to detach only faulted line, it is crucial to differentiate the faults zone precisely and indicate exact fault type with the aid of one end data only [10]. Transient current waves generated by faults contains distinct frequency bands and to capture two bands of frequencies from the transient current signal discrete wavelet transform db1 as a mother wavelet is used. Fault zone is determined by using the frequencies of these two bands. The mother wavelet Haar is used to select faulted phase. Faulted phase was classified by computing the average value of the coefficients of each current wave. A model signal is obtained using db6 as mother wavelet. The decision regarding fault to be external or internal was taken by determining the ratio of two energies for the modal signal. A new scheme for the solution of the parallel transmission line protection problems which depends on the six phase line currents and three phase line voltages of the two parallel circuit lines at both ends is proposed [11]. Fault analysis is done by wavelet transform. And internal faults on double circuit line are recognized by comparing current phasors magnitudes of corresponding phases on each line. It is shown that at different loading conditions each type of fault can be properly recognized.

For the power to be efficiently distributed to different locations, it is necessary to accurately detect and classify the different faults [12]. Active tripping of circuit breaker ensures the accurate protection of transmission line and circuit breakers tripping action depends on the current and voltages waveforms during the fault. For analysis of waveforms of current during fault, Discrete Wavelet Transform (DWT) is used. The evaluation of discrete wavelet analysis for

identification and classification of faults on a transmission line network is done. According to energy level percentage, classification of faults has been done.

The use of wavelet transform for protecting the series compensated line by Current Differential pilot Relay (CDPR) is discussed [13]. Simulation results are obtained using MATLAB and analysis is done using db4 as mother wavelet. Fault classification is done by detecting different types of faults using wavelet based approach. Probability based technique of Bayesian linear discrimination can also be used to differentiate between the different types of faults [14]. An adaptive wavelet algorithm (AWA) is used to generate the wavelets using probability based method of Bayesian linear discrimination. It is shown that adaptive wavelets can be used in the transmission lines of high speed protection system as analysis filters.

Power need to be transmitted from the power station to the load centers located far away [15]. So, the possibility of fault in the transmission lines is considerable. Here, comes the use of signal processing in the digital distance protection. Fourier transform and wavelet transforms are used for locating faults. Simulation is done with MATLAB/SIMULINK. Simulation result shows that wavelet method is more robust tool to locate the faults in the transmission lines. Further it is showed that both wavelet transform and Fourier transform methods can be used to find the characteristics of disrupt signals irrespective of the noise levels present.

The discrete wavelet analysis has been used for the protection of high speed EHV transmission line [16]. An algorithm for fault detection and classification based on discrete wavelet analysis has been presented. By comparing different wavelet coefficients of all three phase signals, type of fault is identified. And simulation is done using ATP-EMTP and MATLAB Wavelet toolbox. Such an algorithm is presented that is not dependent not only on fault location but also on fault inception angle and fault impedance. The algorithm is suitable, strong and quick and this is very prolific for EHV transmission line protection.

For the fault classification and boundary protection of series-compensated transmission lines, a new technique is proposed [17]. Different frequency bands of the wave of transient fault current are detected in order to have the suitable boundary protection. In order to amass the two frequency bands of transient fault current signal, db4 as a mother wavelet is used. Whether the fault is internal or external, it is determined by calculating the spectral energies of two bands of frequencies. Faulted phases are classified by calculating the average value of the wavelet coefficients of every current wave. A simple modal signal is obtained using the fault current values of three phases for all types of faults. Analysis of modal signal is done by using db4 as a mother wavelet, then detail 1 and detail 6 coefficients are calculated of the modal signal. To distinguish whether the fault is internal or external, the ratio of spectral energy is obtained and average values of d6 coefficients of three phase currents and ground current are obtained which is further applied to classify the type of fault.

An impedance based calculation method to locate fault on transmission line is of immense importance [18]. Results get changed by changing line parameters. This is showed by carrying out the analysis of the two widely used methods in real faults. Most commonly used fault location methods are compared and their relative disadvantages and advantages are described. In this manner it becomes simple for the users to go for the most accurate method. Ultimately, it is shown that the two end methods are stronger than the one end methods as sensitivity to errors in two end methods is less as compared to one end methods. Discrete Wavelet Transform (DWT) is used to extract the concealed factors from the fault signals by decomposition at distinctive levels [19]. Daubechies db6 wavelet is used for decomposition at single level. For ground faults a threshold is calculated to classify and detect the faulted phase. The fault location is determined by getting the local fault information, remote fault information and the length of transmission line. The system is considered with negligible fault resistance. A scheme based on wavelet transform for fault classification is proposed [20]. Currents samples from the three lines are used to calculate dWIabc. For different fault inception angles, different fault locations, and different fault distances and for different fault parameters simulation is done by EMTP software. It is shown that magnitude of wavelet transform is valuable to set threshold to discriminate between different types of faults hence to classify the faults. An algorithm based on discrete wavelet transform is developed with C programming [21]. A 500-kv, 200km single line is simulated by using MATLAB. It is shown that as the fault resistance increases, the percentage error increases rapidly. And when, the reactance of the circuit is considered to calculate the distance to fault, then the percentage error in the measurement of distance increases with increase in fault resistance.

This technique decomposed the voltage and current signals at relay location using wavelet filter bank. Fault can be detected and for this distance protection relaying and wavelets are used. Impedances can be calculated at relay location at beginning and 50 km from relay location for single line to ground fault. Wavelet transformation is able to detect the fault as well as estimates the phases at relay location and also successfully classify the every type of fault at any distance various types of faults on transmission line accurately classified within one cycle .Because decomposing is takes place in both time and frequency bands. More study and development on testing the relay for high resistive ground faults gives accurate results [1], [2]. Relay protection required faster response but undesired

operation is not expected be caused it takes more time. To protect the power system from undesired operation , relay system used the transient . And also used longer delayed in relay. be caused longer delay provide more time , due to this as time passes, current amplitude decreases & comes normal condition [3]**.**

3. TRANMISSION LINE PROTECTION SCHEME

Fourier and Walsh transform includes Cosine and Sine-cosine filter. Filtered input is required in wavelet transform .Because it must estimate fast and accurate electrical distance to fault. Power system contains more level of corrupted or distorted signals. Hence area of interest for research is filtering algorithm .hence proposed method provide real information about filter transients behavior of wide range of noise(1) From this paper we find that, when current signals presents DC offset and also contains high frequency damped oscillation, Sine-cosine filter exhibits the best response but Cosine filter provides slightly better performance than sine-cosine filter. Digital relay required low pass anti-aliasing filtering, parameters estimation and tripping decision [4]. They presents Time varying nature of fundamental frequency and harmonic component in frequency are significantly contributes to high impedance fault .The ratio of third harmonic component is approx. to unity .also phase angle of faulty phase 'A' is zero. Where -120 and 120 degree phase angle of phase 'B','C' respectively. The change in low order odd harmonics and their rate of change are significantly contributes to high impedances fault detection .Hence the low order harmonics are less affected by load changes and changes dramatically during high impedances fault condition. Odd harmonics are useful and definite and hence odd harmonics is one of the features of high impedances fault [5]. The wavelet transform provide electromagnetic transients during faults in power system or switching of power system. Frequency domain is useful for investigating source of transient wavelet transform have ability to decompose signal into frequency component. This scheme gives source of transients the property of multi-resolution provide easy and accurate and fast location of fault transient as well as provide information about fundamental frequency and its low order harmonic. This capability can be used in design of automated transient classification system. [6]. The author presents electromagnetic transient program which solve the high impedances fault and capacitor switching operation problem. Wave filter bank differentiate the high impedances and from normal event in distribution system such as capacitor bank switching. Required High pass filter's output as input signal which provide behavior of transient signal. Output of low pass filter smoothen the approximation of input signal. Wavelet analysis filter bank (WAFB) is identifying high impedance fault. WAFB differentiate switching and fault detection. WAFB analyzed the information in two different frequency range component and these can be performed in just two cycle. In future it will be fast and accurate identification. [7]. Author presents that multi-resolution is useful to carry out information of image contain. This is computed with the help of pyramidal algorithm based on quadrature mirror filter. Hence wavelets are used to differentiate several spatial orientation of image.

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4. PROPOSED METHODOLOGY

Presently conventional distance protection is used for transmission line but these protection schemes are also operate during load switching. (e.g. motor, transformer, etc.). This is undesirable condition for protection point of view. This condition is occurs due to high starting inrush current flowing in transmission line, that seen as fault condition for

relay. In these proposed work, new protection scheme design based on multi-resolution analysis which identifies exact fault condition with the help of proper decision tool.

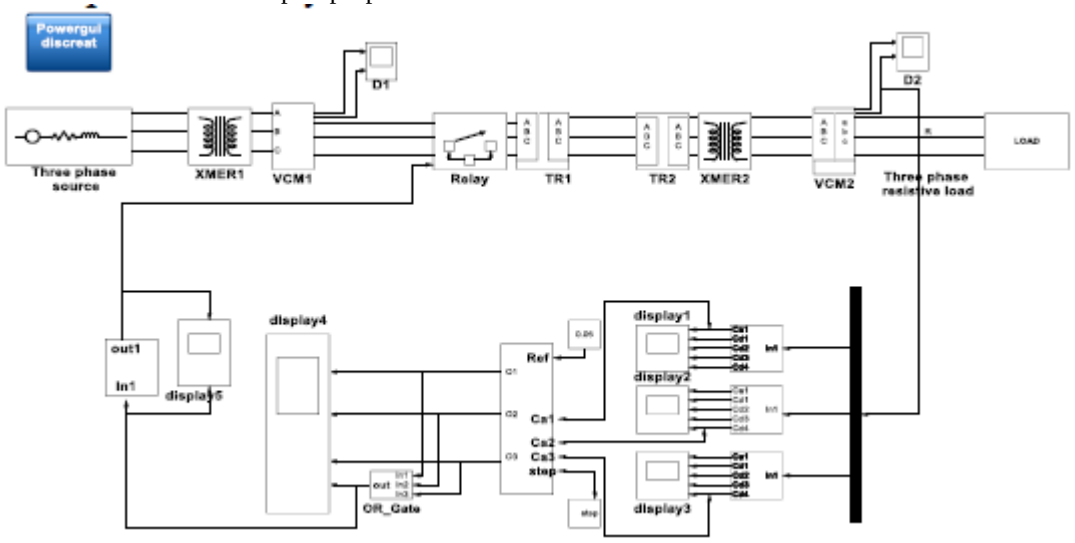

Fig. 1:- Simulation model for the proposed system.

In proposed work, decision tool generates trip signal for circuit breaker for isolating transmission line when abnormal condition is occurs only excluding switching of load. This dissertation presented a non-communication protection technique for transmission lines. The Threshold subsystem technique was employed to classify the faults according to the fault currents components decomposed by the wavelet transform. An application of wavelet transform to digital distance protection of transmission line was presented in this model. Use of wavelet transform gives the ability to detect faults including high impedance fault. Wavelet based distance protection scheme has been tested using MATLAB version 2010 computer simulation model.

Extensive simulation studies are carried out using the MATLAB version 2010 to evaluate the performance of the proposed algorithm under different conditions. The current transformers (CTs) and capacitor voltage transformers (CVTs) are also modeled precisely. The obtained results confirm that the proposed algorithm provides a satisfactory and reliable scheme for the protection of the transmission line even for a small amount of bus equivalent capacitance and variation of the power system parameters. Proposed worked capable to

identify major faults in less than half cycle after fault inception. Present work studied some important factors which influence the operation relay.

5. MATLAB SIMULATION RESULTS

5.1. Result for different fault cases

In these section different types of fault simulated in matlab Simulink model at different location in transmission line model.

Table.2:- Simulation results

Fault types	Distance in Km	Breaker resistance in Ohm	Decision by system (System output)	Required output	Output notations
Normal	3	0.1	NO	NO	0
AG	6	1	YES	YES	1
ABG	6	10	YES	YES	1
AB	9	0.01	YES	YES	1
BG	12	0.001	YES	YES	1
Normal	12	10	NO	NO	0
AG	6	10	YES	YES	1

5.2. Three phase voltage and current waveform

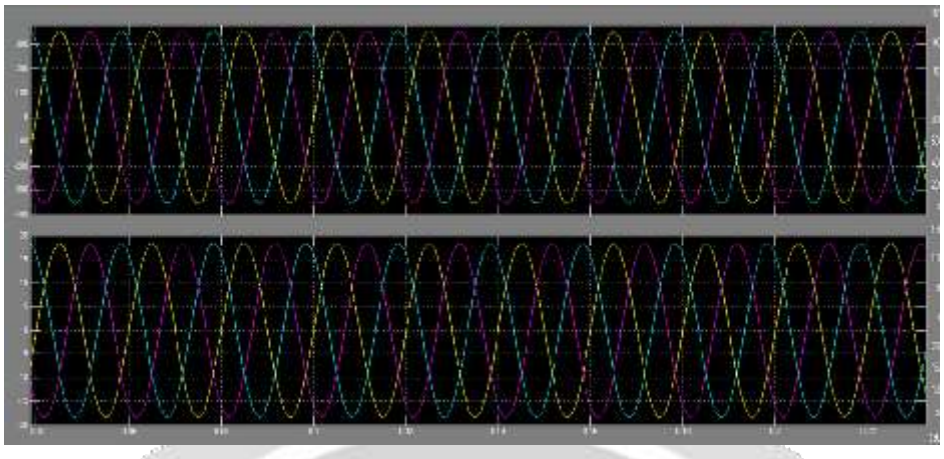

Fig.2:- Three phase voltage and current waveform during normal condition.

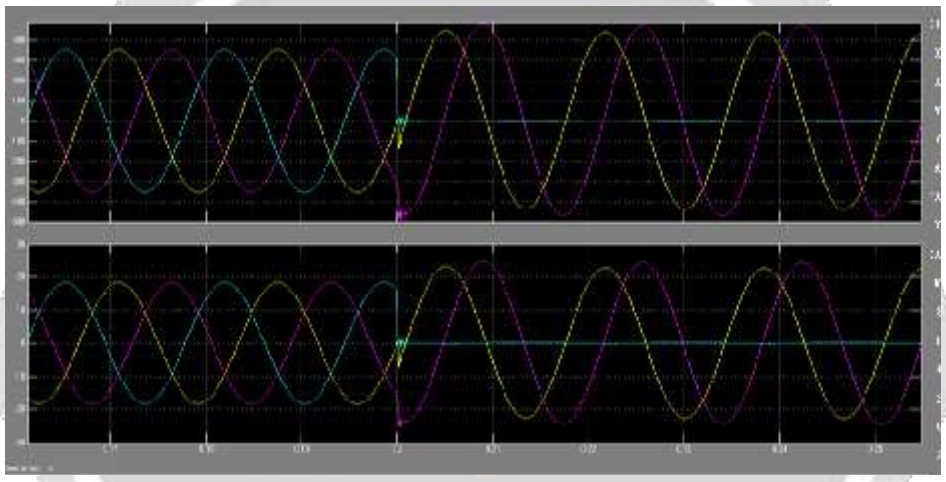

Fig.3:- Three phase voltage and current waveform during line to line fault.

Subsystem2 is use to generate trip signal if there is any detection of fault, and keep trip signal low even fault detection signal goes low, it has memory elements which will keep check on input signal, if at any instants it goes high it will make trip signal low and keep remains low. The simulation model developed in MATLAB for the implementation of the proposed method is shown in figure 1. Simulation model created in Matlab simulink 2010 version simulink model consist of 34.5 KV distributed transmission line. Current measured at load bus utilizing as MRA. Based on MRA the threshold simulation subsystem generator trip signal for circuit breaker.

The simulation result for resistive type of load having its constant of magnitude is 140 used as threshold value is shown in table 2. Figure 2 shows normal transmission line of 34.5 KV but second shows fault occurred in transmission line show by variation with respect to phases. Figure 3 shows decomposition analysis signal from which we can take out more numbers of readings for making threshold algorithm using Daubechis wavelet Db2. Figure 4 shows that reading taken from MRA is used to protect the transmission line as soon as fault is occurred algorithm works and generate the trip signal for circuit breaker to isolate the transmission line.

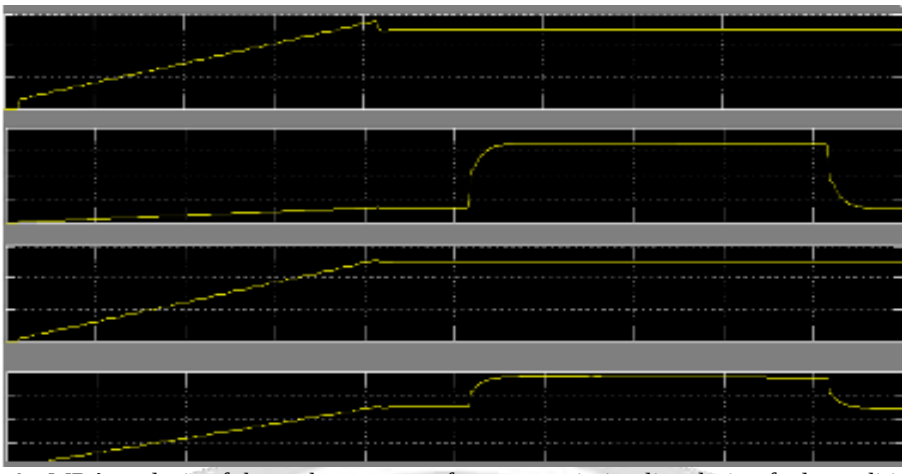

Fig.4:- MRA analysis of three phase current from transmission line during fault condition.

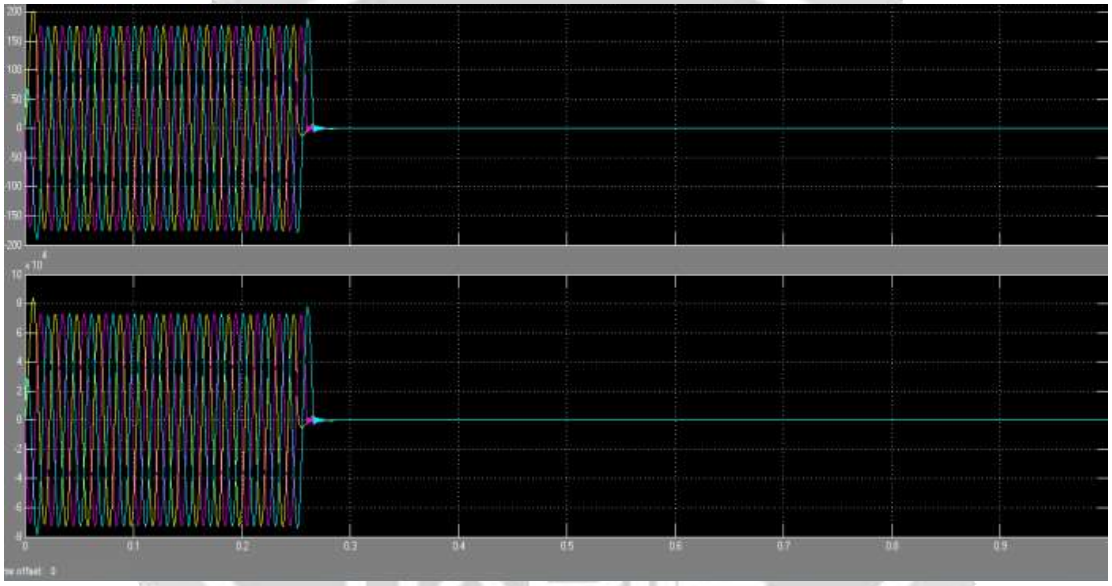

Fig.5:- Fault clearance at 0.25 sec when fault occurs on line.

Wave decomposition block 1-3 is used to apply wavelet to the three phase supply, whose output is cA and cD which is approximation and details, we use cA term into our detection algorithm. Next is subsystem, whose inputs are cA 1 – 3 of three phase supply and reference value and step input, these cA values compares against the reference value if it exceed the reference value output goes to high which indicate the value about the reference value, but due to some uncertain conditions at the start of system output may goes to cross the reference values to protect from going high, a multiplier is use along with step input which keep the output not going to high. OR-gate is use to generate the high signal if there is any fault on any phase, which gives high output if there is any input is high, it is simple or gate logic.

6. CONCLUSION

This paper presented a non-communication protection technique for transmission lines. The threshold subsystem technique was employed to classify the faults according to the fault currents components decomposed by the wavelet transform. An application of wavelet transform to digital distance protection of transmission line was presented in this model. Use of wavelet transform gives the ability to detect faults including high impedance fault. Wavelet based distance protection scheme has been tested using MATLAB version 2010 computer simulation model. Proposed worked capable to identify major faults in less than half cycle after fault inception. Present work studied some important factors which influence the operation relay. Efficiency of this threshold system is up to 92%

calculated from different normal and abnormal 246 cases at different fault location**.** Proposed approach can be extended for protection of double circuit transmission line and multi terminal transmission lines. Proposed approach can be extended with combination of wavelet transform and neural network for power quality observation and fault identification.

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