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TRANSMISSION LINE FAULT DETECTION, CLASSIFICATION AND LOCATION

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Abstract*: The ability to detect, classify and locate the type of fault plays a great role in the protection of power system. This procedure is required to be precise with no time consumption. The disturbances of power systems are aperiodic, non-stationary, very short duration and impulsive in nature. The wavelet transform based approaches have been successfully detected, classify and locate the faults due to their ability to express the signal both in frequency and time domain. This paper describes the implementation of Wavelet Transform analysis on samples of simulated current waveforms obtained from MATLAB for each of the all possible fault scenarios in a modeled 400 kV transmission network.*

I. INTRODUCTION

The quality and continuity of electrical power play an important role in economic activities. Transporting a clean electric power, without interruption, guaranteed a better performances and improved grid stability.. Many utilities around the world are currently in transition towards more competitive market strategies, increasing the quality of the offered service. In this way, the monitoring and analysis of the disturbances, such as transmission line faults, became vital to power system operation.

The transmission lines are part of the principal components of the electrical supply network. Existing transmission lines are forced to operate close to their operating limits. This issue implicates improving the fault clearance times in order to guarantee transient stability. They must be protected against any incident especially the electrical fault conditions. A fault protection system has become fundamentally important due to its ability to prevent economical losses.

Protection features are performed by relays or multifunction devices. The three main protection functions are: detection, classification and localization. The main purpose of a protection system is to process the voltage and/or current signals to determine whether a fault is present, to classify what kind of fault it may be, to estimate the fault location, and to take action to remove the fault from the power transmission-line system as fast and accurate as possible to de-energize the system from the harmful faults and restore the system after faults. The continuity service depends heavily on the possibility of detecting, classifying, locating, and isolating faults in the power transmission-line system. The time required to determine the fault location will affect the quality of the protection relay. Therefore, fast and accurate fault identification is an important requirement for the transmission line protection.

Introduction of circuit breaker and protective relays. Protective relay are broadly classified into the following three categories depending on the technologies they use for their construction and operation, electromechanical relays, static relay and numerical relay. Over a past 30 year, many studies have been done on the transmission-line protection including fault detection, classification, and location and arcing fault discrimination for avoiding reclosing on a permanent fault. Based on fault transients, several algorithms have been reported for fault detection and classification.

II. APPLICATION OF WAVELET TRANSFORM IN PROTECTION RELAYING

For the last several years, Fourier transform has been extensively used by many researchers in the field of power system protection. However, when a signal is transformed to the frequency domain, the time domain information is lost, which is a serious drawback with Fourier transform. Fault signal contain numerous non-stationary or transitory characteristics. These characteristics are often very significant in the signal, and Fourier analysis is not suited for their detection. Wavelet transform are capable of revealing those aspects of data are usually missed by other signal analysis techniques. Furthermore, as wavelet analysis provides information in both frequency and time, it can compress or de-noise a signal without appreciable degradation [1].

III. DISCRETE WAVELET TRANSFORM

The discrete wavelet transform (DWT) uses filter banks for the construction of the time-frequency plane.

A filter bank consists of filters which separate a signal into frequency bands. An example of a two channel filter bank is shown in Fig. 1. A discrete time signal x(k) enters the analysis bank and is filtered by the filters L(z) and H(z) which separate the frequency content of the input signal in frequency bands of equal width. The filters L(z) and H(z) are therefore respectively a low-pass and a high-pass filter. The outputs of the filters each contain half the frequency content, but an equal amount of samples as the input signal. The two outputs together contain the same frequency as the input signal. However the amount of data is doubled. The different output signals of the analysis filter bank are called sub-bands, the filter-bank technique is also called sub-band coding.

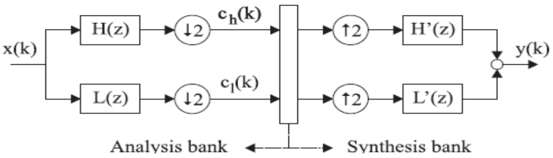

Fig. 1 Two channel filter bank

One level of decomposition can mathematically be expressed as follows:

$$y_{high}[k] = \sum_n x[n] \,.\, g[2k - n] \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$y_{low}[k] = \sum_n x[n] \,.\, h[2k - n] \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

where $y_{high}[k]$ and $y_{low}[k]$ are the outputs of the high-pass and low-pass filters respectively, after sub sampling by 2.

Fault Detection

Transient signals have some characteristics such as high frequency and instant break, so wavelet transform is strong tool for them in feature picking-up, and it satisfies the analysis need of electric power transient signals. DWT is determining by filtering the signal with a high-pass and low-pass filter pair. Filtering by high-pass filter produces details and filtering by low-pass produces approximations [2].

Let current signal S (t), which is a discrete sequence with n samples, be the signal sequence to be analyzed as follows.

1) First, analyze the S (t) by DWT, where the "db4" mother wavelet and find 1st level decomposition coefficient, as Dj is detail coefficient and Aj is approximation coefficient.

2) Second, find wavelet energy spectrum Ej as

$$Ej=|Dj|^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots.(4)$$

3) Third, in order to obtain the entropy of the signal, the probability p_i is defined as follows:

$$p_i = Ei / \sum_{j=1}^{r} E_j \quad \ldots\ldots\ldots\ldots(5)$$

where r is number of detail coefficient Dj.

4) Finally, Wavelet Energy Entropy (WEE) of S (t) is obtained by

$$WEE = - \sum_{i=1}^{r} p_i ln\, p_i \quad \ldots\ldots..(6)$$

WEE is sensitive to the transients produced by the faults. Therefore, the proposed WEE will be suitable and useful for measuring the uncertainty and complexity of the analyzed signals, and will provide an intuitive and quantitative outcome for the fault diagnosis.

Fault Classification

Discrete Wavelet Transform (DWT) has been used for detecting and classifying faults on transmission lines. For detection and classification of faults on transmission lines different types of faults at different locations on the line were simulated and their current signals were sampled at regular intervals of time. These samples are passed through a high pass (g[n]) and a low pass (h[n]) filter. The low pass filters here give us the coefficients for the wavelet transform. The DWT coefficients for Db-4 wavelet corresponding to 1st level for the three phase currents are used in the analysis [3].

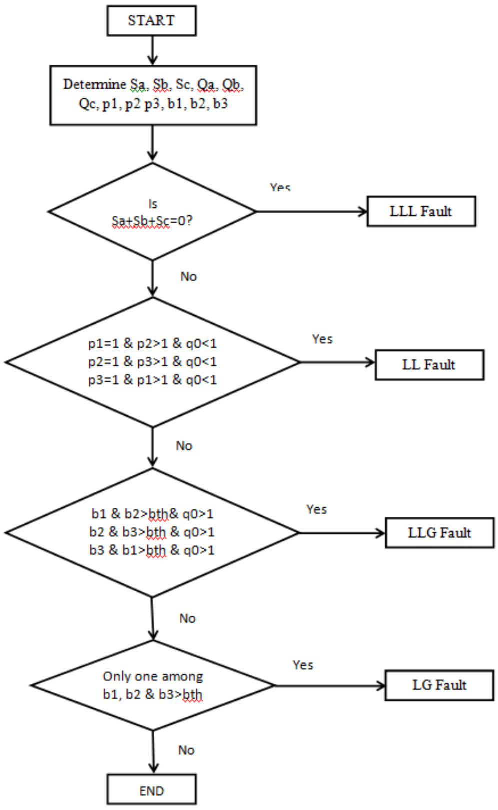

Fig 2 Fault classification algorithm using DWT

For classification using DWT a few parameters are defined as given below:
Sa= Summation of 3rd level coefficients for phase A.
Sb= Summation of 3rd level coefficients for phase B.
Sc= Summation of 3rd level coefficients for phase C.
The parameters Qa, Qb and Qc are defined as:
Qa= Summation of absolute values of 3rd level coefficients for phase A.
Qb= Summation of absolute values of 3rd level coefficients for phase B.
Qc= Summation of absolute values of 3rd level coefficients for phase C.
The ratios P1, P2 and P3 are defined as:
P1 = Qa/Qb, P2 = Qb/Qc and P3 = Qc/Qa.
The indicator b1, b2 and b3 are defined as:
b1 = Qa/Qb + Qa/Qc
b2 = Qb/Qa + Qb/Qc and
b3 = Qc/Qa + Qc/Qb.
bth is defined as a threshold value, which can be taken as max(b1, b2, b3) for the maximum safe value of current through the transmission line. The algorithm for the classification of faults using DWT is given in Fig. 2. According to this algorithm all fault can be classify accurately.

Simplified Model of the Transmission Line

A typical model of a 400-kV and 300-km EHV transmission line with one power source is established in MATLAB, as shown in Fig. The sending end (SE) is modeled as Synchronous machine and the receiving end (RE) are modeled as a three-phase series RLC load. In normal condition, power is transferred from SE to RE through a line having three section, each of 100-km length. Lines are modeled with distributed parameters in the simulation.

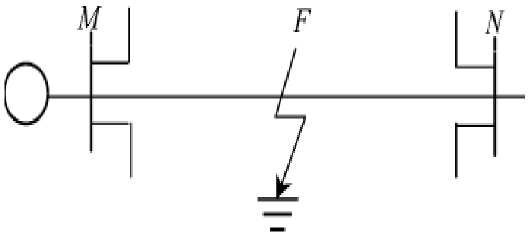

Fig. 3 Simplified Model of the Transmission Line

Transmission Line Model in MATLAB

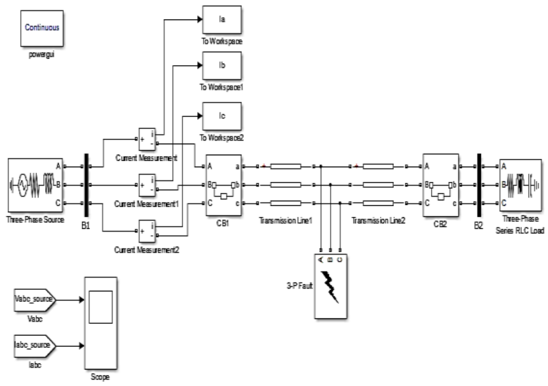

Fig. 4 Transmission Line Model in MATLAB

Fault Detection Tests Results in Simulation

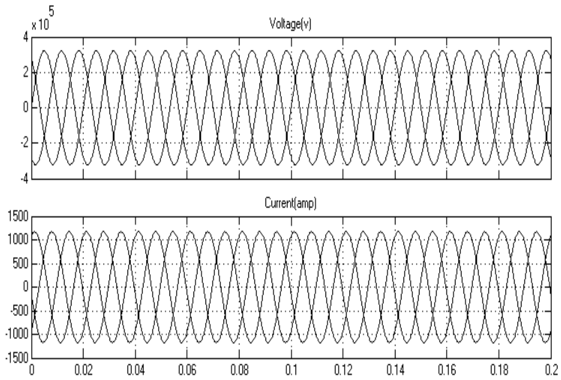

Fig. 5 Voltage and Current Waveform during Normal Condition

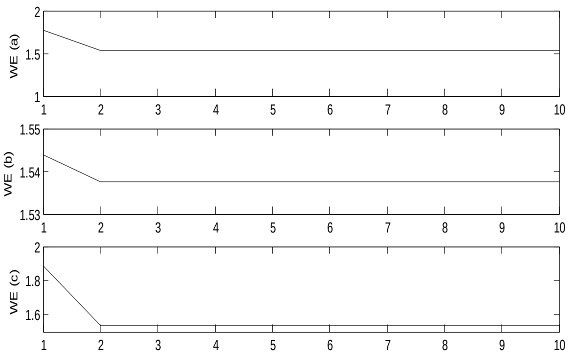

Fig. 6 Wavelet Entropy of 3-Phase Current Signal during normal condition

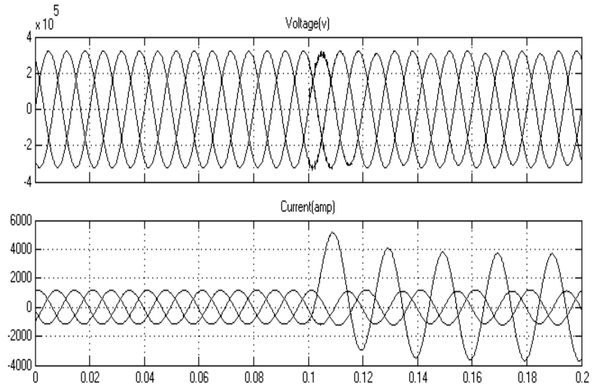

Fig. 7 Voltage and Current Waveform during L-G Fault

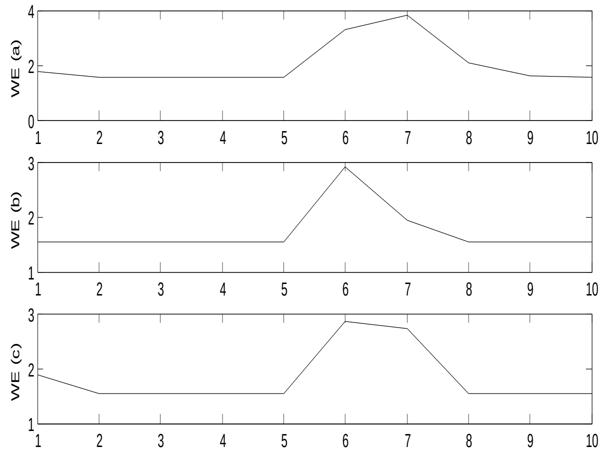

Fig. 8 Wavelet Entropy of 3-Phase Current Signal for L-G fault

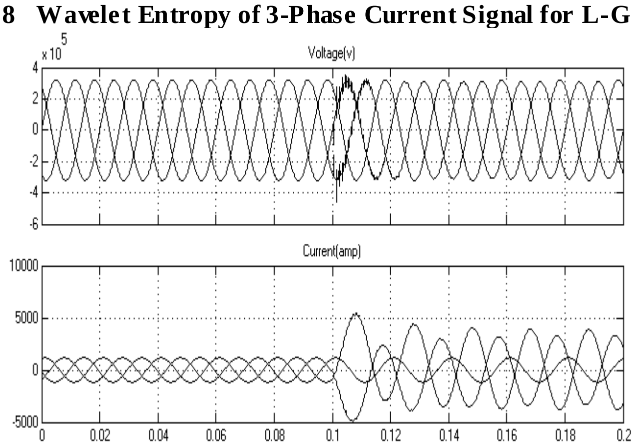

Fig. 9 Voltage and Current Waveform during L-L Fault

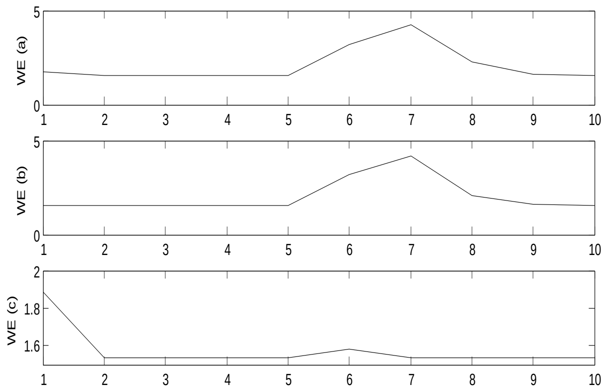

Fig. 10 Wavelet Entropy of 3-Phase Current Signal for L-L Fault

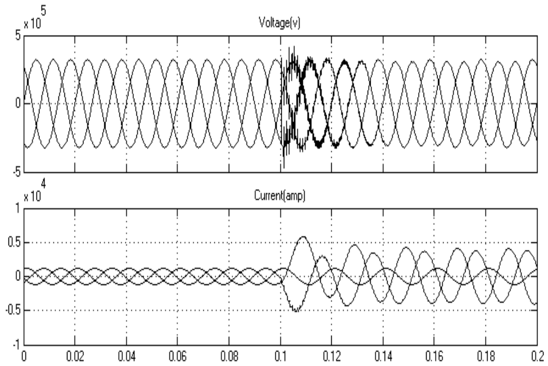

Fig. 11Voltage and Current Waveform during L-L-G Fault

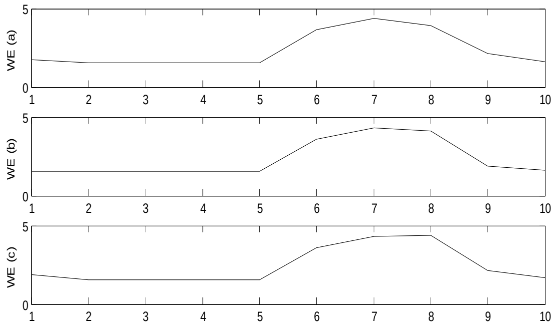

Fig. 12 Wavelet Entropy of 3-Phase Current Signal for L-L-G Fault

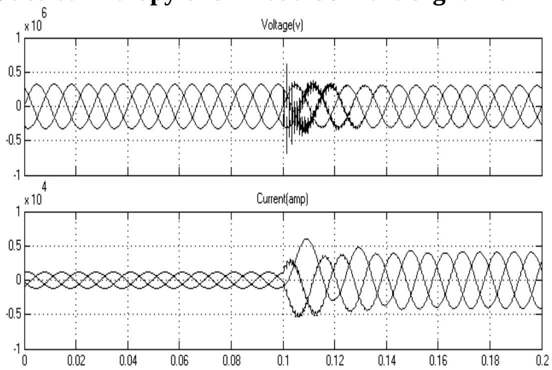

Fig. 13 Voltage and Current Waveform during L-L-L Fault

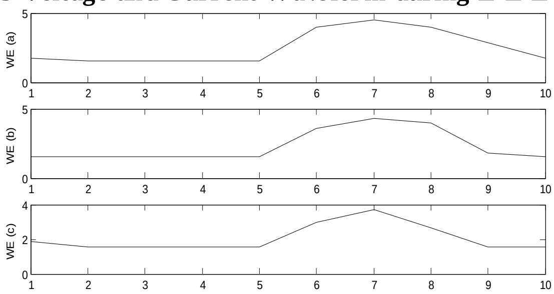

Fig. 14 Wavelet Entropy of 3-Phase Current Signal for L-L-L Fault

A typical model of a 400-kV and 300-km EHV transmission line is established in MATLAB, as shown in Fig. Assume that a single-phase-to-ground fault occurs at t=5ms. Set the sampling frequency to be 20 kHz, take 400 sample-log sequence.

The simulation results are shown in Figures from which we can see that the values of the current have a sudden saltation at about 0.1 s. A large number of simulation tests have been carried out and the results show that the WSE bears good capability for fault detection in the EHV transmission line.
The system shown in Fig. 5.2 is used for simulation tests. The current transient of each phase, which is measured in one end, is analyzed in the case of fault classification. The sampling frequency is set to be 20 kHz and the “db4” mother wavelet and take the 400-sample-long sequence (i.e., full-cycle data after fault inception) as the input of wavelet

transform. The test results for various fault types, various fault inception angles, and various fault locations are shown from Tables 1–5.

Table 1 Values of Sa, Sb, Sc And Sa+Sb+ScinCaseof LLL Fault for different fault distance

Fault Location	Sa	Sb	Sc	Sa+Sb +Sc	Qo
10	-1.0196	35.7701	34.75	6.2e-11	3.34e-10
50	0.0675	-0.0193	-0.0482	1.6e-11	1.58e-10
100	-0.5016	-3.4854	3.9870	1.2e-11	1.31e-10
150	1.5016	3.831	-5.33	-1.5e-12	5.5e-10
200	2.3058	2.7935	5.0993	2.2e-12	9.17e-12
250	-0.1941	-0.0938	0.2879	1.3e-12	8.3e-11
290	-0.3407	-0.025	-0.366	-3.6e-12	3.8e-11

Table 2 Values of Sa, Sb, Sc and Sa+Sb+Sc in Case of LLL Fault for different Inception Angle at a Distance of 20km

Inception Angle	Sa	Sb	Sc	Sa+Sb+Sc	Qo
20	0.2317	0.1743	-0.4060	-3.0724e-12	1.6154e-11
80	-0.0046	0.0111	-0.0065	1.5531e-12	2.1530e-11
140	0.9731	-0.5654	-0.4078	-3.6393e-13	9.3428e-11
170	9.7332	-1.0179	-8.7153	1.4442e-12	4.7716e-11

Table 3 Range of Values of P1, P2 and P3 For all Values of Distance and Inception Angle in Case of LL Fault on Phase A-B

	P1	P2	P3	Qo
Max	1.0000	2.674e+4	0.0073	0.0592
Min	0.9634	18.502	3.7e-4	0.0143

Table 4 Range of Values of b1, b2 and b3 for all Values of Distance and Inception Angle in Case of LG Fault on Phase A-G

	b1	b2	b3
Max	15.85	1.85	1.29
Min	6.15	1.26	0.81

Table 5 Range of Values of b1, b2 and b3 for all Values of Distance and Inception Angle in Case of LLG Fault on Phase AB-G

	b1	b2	b3	Qo
Max	12.73	14.12	1.53	966.19
Min	2.28	2.32	0.16	191.20

IV. CONCLUSION

For this project work made a model for 400kV transmission line and simulated the Different fault under different conditions. Wavelet Entropy shows a good detecting ability in transmission line fault detection. From the results presented it is clear that DWT technique gives better results in case of fault classification. This proposed fault classification algorithm is provided with high accuracy and is immune to different conditions, such as fault types, fault inception angles, and fault locations, etc.

APPENDIX

The parameters of the system used for simulation are given as below [4].

Three-Phase Source of 400kv

Transmission lines:

Frequency = 50Hz

Z1=0.12+j0.88 ohm/km.

Z0=0.309+j1.297ohm/km.

C1=1.0876*10^-8 F/km.

Line length = 2 line 0f 150km

Three-Phase series RLC load of 10kw

REFERENCES:

Periodicals:

1. BhaveshBhalja, R. P. Maheshwari, Nilesh G. Chothani, “Protection and Switchgear”, First edition, Oxford University Press, New Delhi, 2011

2. He Zheng-you; Chen Xiaoqing; Fu Ling, "Wavelet Entropy Measure Definition and Its Application for Transmission Line Fault Detection and Identification; (Part II: Fault Detection in Transmission line)," *Power System Technology, 2006. PowerCon 2006. International Conference on*, pp.1-5, 22-26 Oct. 2006

3. He Zheng-you; Chen Xiaoqing; LuoGuoming, "Wavelet Entropy Measure Definition and Its Application for Transmission Line Fault Detection and Identification; (Part I: Definition and Methodology)," *Power System Technology, 2006. PowerCon 2006. International Conference on* , pp.1,6, 22-26 Oct. 2006

4. Sheng, Y. “Wavelet Transform.” *The Transforms and Applications Handbook: Second Edition.* Ed. Alexander D. Poularikas Boca Raton: CRC Press LLC, 2000

5. K. M. Silva, B. A. Souza, and N. S. D. Brito, “Fault detection and classification in transmission lines based on wavelet transform and ANN,” *IEEE Trans. Power Del.*, vol. 21, no. 4, pp. 2058–2063, Oct. 2006

6. A. I. Megahed, A. M. Moussa, and A. E. Bayoumy, “Usage of wavelet transform in the protection of series-compensated transmission lines,” *IEEE Trans. Power Del.*, vol. 21, no. 3, pp. 1213–1221, Jul. 2006.

7. Jianyi Chen; Aggarwal, R.K., "A new approach to EHV transmission line fault classification and fault detection based on the wavelet transform and artificial intelligence," *Power and Energy Society General Meeting, 2012 IEEE* , vol., no., pp.1,8, 22-26 July 2012

Books:

1. BhaveshBhalja, R. P. Maheshwari, Nilesh G. Chothani, "Protection and Switchgear", First edition, Oxford University Press, New Delhi, 2011

2. Badri Ram, D N Vishwakarma, "Power Sysstem Protection and Switchgear", Second edition, McGraw Hill Education pvt. Ltd., New Delhi, 2013.

