Wavelet Transform Based Relaying Scheme for Double Circuit Transmission Line Protection

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***Abstract* - An application of wavelet transform based multi resolution analysis approach for double circuit transmission line protection from various faults is revealed in this paper, to intensify the result of various problems linked with distance security of double circuit transmission lines. The fault current signal is explored by choosing wavelet transform program of MATLAB and selecting 'db4' as mother wavelet to retrieve the fault current coefficients for fault detection in double circuit transmission line. Results of simulation work displays that the proposed relay based on wavelet transform can lift the work of orthodox protection schemes.**

Index Terms - Double circuit transmission lines, relaying schemes, wavelet transform, fault detection, location, and classification.

I. PREFACE

Multi terminal transmission lines are entirely standard owing to the growth of power transmission system both in convolution and expanse. Nevertheless, a double circuit transmission line constitutes unusual issues due to multi-terminals. On this subject, Adel Aktaibi et al. in [1] proposed a hybrid technique which consists of WPT and dq-axis components for current differential protection of transmission lines. . In their work, they developed and implemented hybrid technique by localizing frequency sub-bands of dq-axis components of the differential currents using WPT for finding out the best signature of the internal faults. P.D. Raval et al. in [2] proposed a method for series capacitor compensated multi bus EHV transmission system protection by using PNN. A classification of various types of transmission line faults has been done by the usage of PNN technique. Wavelet transform has been used for feature extraction of current signals. Y. Manju Sree et al. in [3] developed a protection scheme for multi-terminal transmission lines combined with wind energy source. Wavelet transform technique has been used for the analysis of different types of faults. In [4] Tamer S. Abdelgayed et al. developed a new technique based on harmony search algorithm (HSA) for determining suitable wavelet functions for the transmission line fault classification. Ahmad Abdullah in [5] developed a wavelet based neural network algorithm for classifying transients which include transmission line faults on protected and adjacent transmission line. In [6] Ahmad Abdullah proposed wavelet entropy based lightning fault detection on transmission lines. Ahmed R. Adly et al. in [7] proposed a fault identification algorithm for fault discrimination, classification and faulty phase selection of a high voltage transmission line. Ozkan Altay et al [8] developed and proposed a scheme that uses single end travelling wave fault location on transmission line by the usage of wavelet analysis without using the velocity of propagation. Saeed Asghari Govar and Heresh Seyedi in [9] proposed an adaptive CWT based differential protection of transmission line for cross country faults considering current transformer saturation. In [10] J. Uday Bhaskar et al. presented a wavelet and fuzzy based protection scheme for the protection of three terminal transmission systems. Suman Devi et al. in [11] presented a DWT based scheme for transmission line fault detection. Xinzhou Dong et al. in [12] presented a principal of directional comparison based on travelling wave. Xinzhou Dong et al. in [13] implemented and applied directional protection based travelling wave theory in UHV transmission line. An algorithm based on singular value and Euclidean norm for the fault detection and classification in transmission lines has been developed by Daniel Guillen et al. in [14]. The algorithm has been developed by using DWT and singular value decomposition (SVD). Daniel Guillen et al. in [15] wavelet singular entropy (WSE) technique has been developed for the detection and classification of transmission line faults. Fault classification has been done through the Euclidean norm based on the all phases WSE information. A procedure for double circuit transmission line fault detection using wavelet transform is the main intention of this paper. Simulations results of MATLAB/Simulink demonstrate that the proposed wavelet transform scheme for double circuit transmission line protection provides precise response in various fault scenarios.

II. SIMULATION STUDIES

The system accommodates three phase transmission line of 200 km length having double circuits fed by three phase 400 kV, 50 Hz voltage source as shown in Fig. 1. Simulation of a double circuit transmission line model has been done by utilizing MATLAB's SimPowerSystems toolbox.

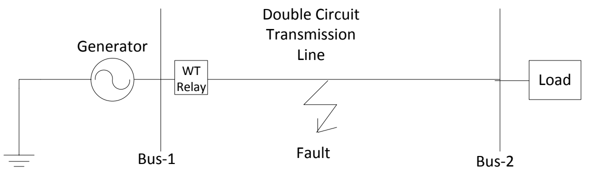

Fig. 1 Single line diagram under task

III. WAVELET TRANSFORM BASED RELAYING SCHEME

For analyzing high frequencies, the signal is passed through high pass series connected filters and for analyzing low frequencies, the signal is passed through low pass series connected filters. For any function (f) DWT is drafted as:

$$DWT\psi f(m.k) = \frac{1}{\sqrt{a_0^m}} \sum_n x(n)\, \psi[\frac{k-n_0 b_0 a^m}{a_0^m}] \quad (1)$$

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Where the mother wavelet can be connote by Ψ, the scale parameters can be expressed as a_0^m and the parameter of translation is designated as a^m, n_0, b_0.

The subsequent equation also defines WT:-

$$\Omega(\varphi,\kappa) = \sum_j \sum_k x(k) 2^{-\frac{j}{2}} \varphi(2^{-j} n - k) \qquad (2)$$

Where a mother wavelet is designated as φ (t) having finite energy which is a function of time.

Each sub band is accommodated with the neighbouring immense frequency sub band half of the samples [18-21].

$$\psi_H [\kappa] = \sum_n x[n] g[2k - n] \qquad (3)$$

$$\Psi_\Lambda [\kappa] = \sum_n x[n] h[2k - n] \qquad (4)$$

Where y_H [k] and y_L[k] is the high pass (g) and low pass (h) filters gain, after sub sampling by twice.

By gathering the one full cycle window of sampled information of each consistent signal of current, initiation of the recommended scheme has been done. Testing of WT based fault detection strategy has been done on the developed MATLAB model of double circuit transmission line. Following current measurement of all three phases, wavelet analysis (using 'db4' wavelet) of three phase current has been done for their decomposition and extracting high frequency detailed coefficients and after that summation of the square of the detailed coefficients has been done including calculation of wavelet energy of each phase. The relaying scheme is shown in Fig. 2

IV. SIMULATION RESULTS OF WT BASED FAULT DETECTOR

Wavelet transform based fault detection strategy has been tested in MATLAB/Simulink model of double circuit transmission line [22]. Four types of cases has been studied- normal operating condition (no fault condition), single line to ground fault operating condition (phase-A1G fault), double line to ground fault operating condition (phase-A1A2G fault) and triple line to ground fault operating condition (phase-B1B2C2G fault). Simulation results of WT based fault detector relay during healthy condition is shown in Fig.3 and it constitutes plots of line current, its decomposition coefficient and detail coefficient at level-1. Fig.4-9 demonstrates simulation results of relay during phase-A1G (single line to ground) fault condition. Table-1 and 2 summarizes relay output during healthy and phase-A1G fault operating condition. The relay output includes detail coefficients at level-1 ($C_{a,\ b,\ c}$ D_1), energy level ($E_{a,\ b,\ c}$) and sum of squares of detail coefficients at level-1 of each phase

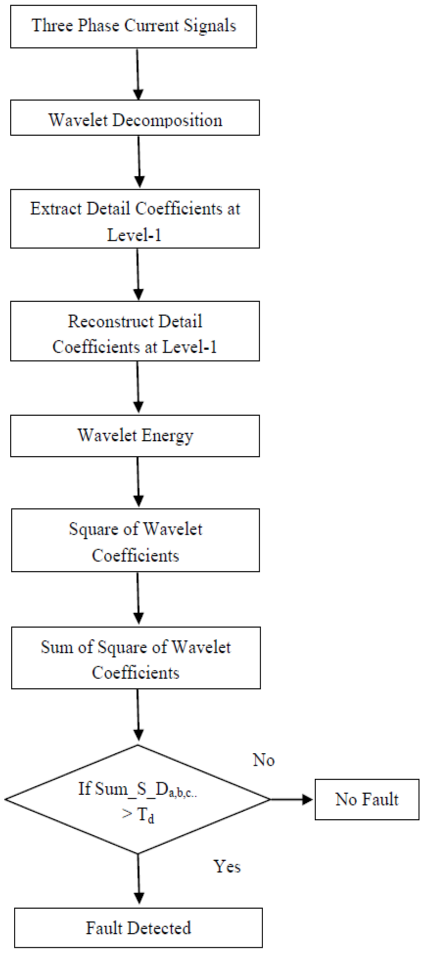

Fig. 2 Scheme for fault detection

(Sum_S_Da_1, D_{b1}, D_{c1}) of a double circuit transmission line. From Table-1 and 2 it can be seen that during the fault inception the magnitude of detail coefficient, energy and sum of square of detail coefficient of faulty phase (s) increases in comparison to the relay output during healthy condition. For example, the magnitudes of detail coefficient, energy and sum of square of detail coefficients in healthy condition are 0.0017, 99.3461 and 2.3219*10^-5. But on the application of phase-A1G fault the magnitudes of detail coefficient, energy and sum of square of detail coefficients are 145.0327, 99.7841 and 4.3625*10^5. The DWT based fault detector exploits this change. It is clear from Table-1 and 2 that during healthy condition the magnitude of detail coefficient, energy and sum of square of detail coefficient of all phases is very much less in comparison to that after fault inception. Thus, DWT based fault detector is able to differentiate between healthy and faulty condition and it easily detects fault [23].

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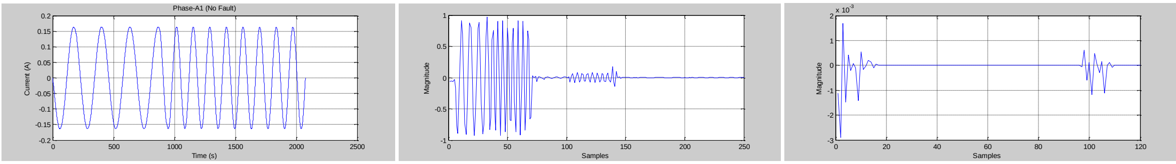

Fig. 3 Phase_A1 current, its wavelet decomposition and detail coefficient during healthy condition

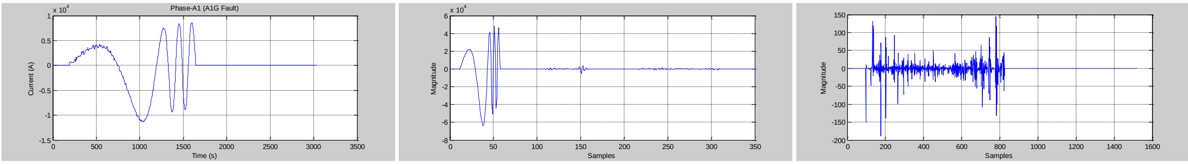

Fig. 4 Phase-A1 current, its wavelet decomposition and detail coefficient during A1G fault condition

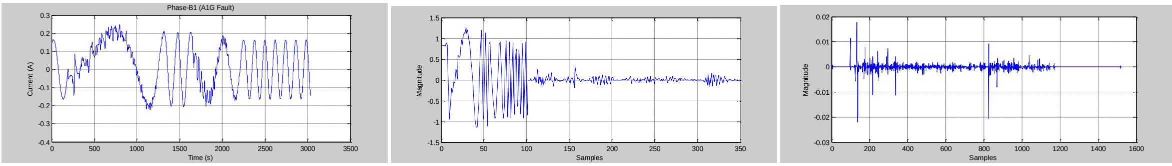

Fig. 5 Phase-B1 current, its wavelet decomposition and detail coefficient during A1G fault condition

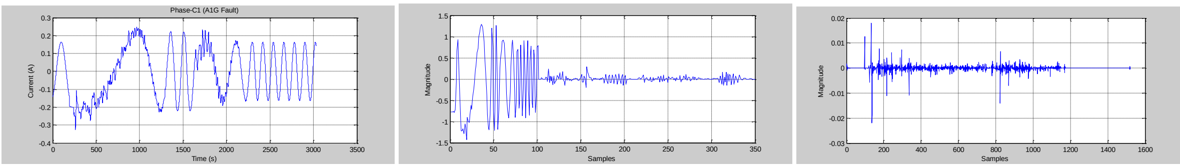

Fig. 6 Phase-C1 current, its wavelet decomposition and detail coefficient during A1G fault condition

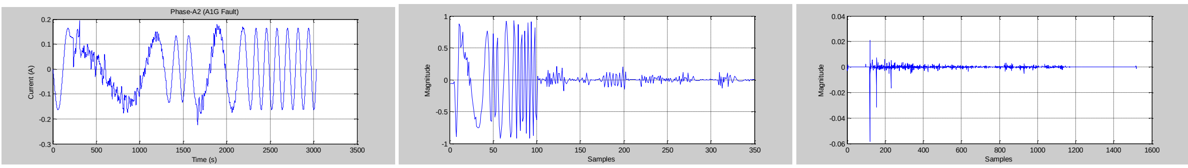

Fig. 7 Phase-A2 current, its wavelet decomposition and detail coefficient during A1G fault condition

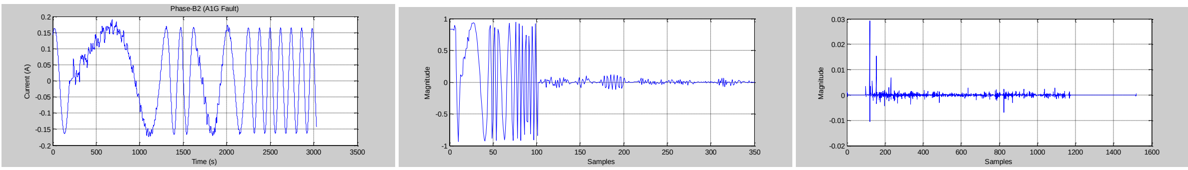

Fig. 8 Phase-B2 current, its wavelet decomposition and detail coefficient during A1G fault condition

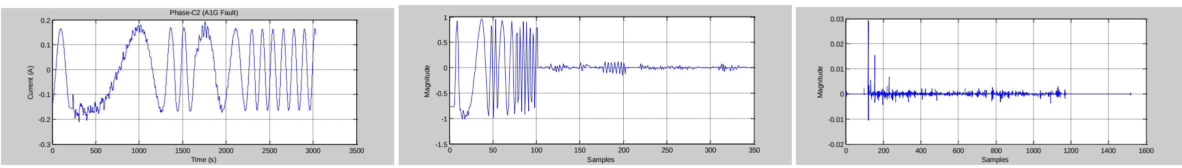

Fig. 9 Phase-C2 current, its wavelet decomposition and detail coefficient during A1G fault condition

TABLE 1 RELAY OUTPUT DURING HEALTHY CONDITION

OUTPUTS	**PHASES**					
	A1	**B1**	**C1**	**A2**	**B2**	**C2**
$C_{a, b, c}$ D_1	0.0017	0.0017	0.0016	0.0017	0.0017	0.0016
$E_{a, b, c}$	99.3461	99.6224	99.5312	99.3461	99.6224	99.5312
Sum_S_Da_1, D_{b1}, D_{c1}	2.3219*10^-5	1.7902*10^-5	1.5929*10^-5	2.3219*10^-5	1.7902*10-5	1.5929*10^-5

TABLE 2 RELAY OUTPUT DURING PHASE – A1G FAULT CONDITION

OUTPUTS	PHASES					
	A1	**B1**	**C1**	**A2**	**B2**	**C2**
$C_{a, b, c}$ D_1	**145.0327**	0.0179	0.0179	0.0209	0.0293	0.0292
$E_{a, b, c}$	**99.7841**	98.0099	98.3003	97.6424	99.1634	99.1931
Sum_S_Da_1, D_{b1}, D_{c1}	**4.3625*10^5**	0.0036	0.0033	0.0064	0.0019	0.0018

V. CONCLUSION

Wavelet transform based double circuit transmission line fault detection layout is presented in this paper and tested for various types of faults. For different system circumstances and parameters a 400 kV, double circuit transmission line of 50 Hz frequency and 200 km length is simulated by using MATLAB software. The proposed scheme correctly detects the faulty phase based on the simulation results for all the cases that have been tested by using MATLAB software.

REFERENCES

[1] Adel Aktaibi, Glyn George and M. A. Rahman, "A High-Speed Digital Current Differential Protection Algorithm for Power Transmission Lines in Smart Grids", *IEEE-EPEC-2016*, October 2016

[2] P. D. Rawal and A.S.Pandya, "Accurate Fault Classification in Series Compensated Multi-Terminal Extra High Voltage Transmission Line using Probabilistic Neural Network", *IEEE-ICEEOT-2016*, pp. 1550-1554, 2016

[3] Y. Manju Sree, G.Ravi kumar and Abdul Gafoor Shaik, "Multi-Terminal Transmission Line Protection using Wavelet Based Digital Relay in the Presence of Wind Energy Source", *IEEE-ICEEOT-2016*, pp. 4124-4128, 2016

[4] Tamer S. Abdelgayed, Walid G. Morsi and T S Sidhu, "A New Harmony Search Approach for Optimal Wavelets Applied to Fault Classification", *IEEE Transactions on Smart Grid*, pp. 1-9, 2016

[5] Ahmad Abdullah, "Towards a New Paradigm for Ultrafast Transmission Line Relaying", *IEEE-PECI-2016*, April 2016

[6] Ahmad Abdullah, "A Wavelet Entropy Approach for Detecting Lightning Faults on Transmission Lines", *IEEE/PES-T&D-2016*, July 2016

[7] Ahmed R. Adly, Ragab A. El Sehiemy, Almoataz Youssef Abdelaziz and Nabil M.A. Ayad, "Critical Aspects on Wavelet Transforms based Fault Identification Procedures in HV Transmission Line", *IEEE-IET-2015*, pp. 1-10, September-2015

[8] Ozkan A. Itay, Ekrem Gurso and Ozcan Kalenderli, "Single End Travelling Wave Fault Location on Transmission Systems using Wavelet Analysis", *IEEE-ICHVE-2014*, February 2015

[9] Saeed Asghari Govar and Heresh Seyedi, "Adaptive CWT-based Transmission Line Differential Protection Scheme considering Cross-Country Faults and CT Saturation", *IEEE-IET-GTD-2016*, pp. 2035-2041, Vol. 10, March-2016

[10] J. Uday Bhaskar, Sk. Abdul Gafoor and J.Amarnath, "Wavelet Fuzzy based Fault Location Estimation in a Three Terminal Transmission System", *IEEE-ICACCS-2015*, January-2015

[11] Suman Devi et al., "Detection of Transmission Line Faults using Discrete Wavelet Transform", *IEEE-CASP-2016*, pp. 133-138, June-2016

[12] Xinzhou Dong, Shenxing Shi, Bin Wang and Shiyong Wang, Li Ren, "Travelling Wave based Directional Comparison Protection Scheme and its Application in 750 kV Transmission Lines", *IEEE-PESGM-2015*, August 2015

[13] Xinzhou Dong et al., "Implementation and Application of Practical Travelling Wave based Directional Protection in UHV Transmission Lines", *IEEE Transactions on Power Delivery*, pp. 1-9, 2015

[14] Daniel Guillen et al., "Detection and Classification of Faults in Transmission Lines using the Maximum Wavelet Singular Value and Euclidean Norm", *IEEE-IET-GTD*-2015, pp. 2294-2302, vol.-9, July-2015

[15] Daniel Guillen et al., "Fault Detection and Classification in Transmission Line Using the Euclidian Norm of the Total WES", *IEEE/PES-PEST&D-LA-2014*, November 2014

[16] Ahmed Hossam Eldin, Ahmed Lotfy, Mohammed Elgamal and Mohammed Ebeed, "Combined Travelling Wave and Fuzzy Logic based Fault Location in Multi-Terminal HVDC Systems", *IEEE-EEEIC-2016*, September 2016

[17] Mohammad Amin Jarrahi, Haidar Samet and Ali Sahebi, "An EMD based Fault Type Identification Scheme in Transmission Line", *IEEE-ICEE-2016*, pp. 422-427, 2016

[18] Bhupendra Kumar and Anamika Yadav, "Wavelet Singular Entropy Approach for Fault Detection and Classification of Transmission Line Compensated with UPFC", *IEEE-ICICES-2016*, 2016

[19] M. N. Mahmud, M.N. Ibrahim, M.K. Osman and Z. Hussain, "Selection of Suitable Features for Fault Classification in Transmission Line", IEEE-ICCSCE-2015, pp. 591-596, November-2015

[20] F. Namdari and M. Salehi, "A High Speed Protection Scheme based on Initial Current Travelling Wave for Transmission Lines Employing Mathematical Morphology", *IEEE Transactions on Power Delivery*, pp. 1-8, 2016

[21] Robi Polikar, "The Engineer's Ultimate Guide to Wavelet Analysis",http://engineering.rowan.edu/polikar/WAVELETS/WT tutorial.html

[22] Trilok Soni, Abhishek Jain, Gaurav Kapoor and Dinesh Birla, "Discrete Wavelet Transform Based Fault Location in Double Circuit Transmission Line", *IJEECS*, vol. 6, no. 3, pp. 49-54, March-2017

[23] Gaurav Kapoor, Dinesh Birla and Sumit Tripathi, "Discrete Wavelet Transform in Series Compensated Transmission Line for Fault Location", *IJEECS*, vol. 6, no. 3, pp. 110-115, March-2017