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FAULT DETECTION OF POWER TRANSFORMER BY USING WAVELET TRANSFORMS

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ABSTRACT

A new approach for protection of power transformer is presented using a time-frequency transform known as Wavelet transform. Different operating conditions such as inrush, Normal, load, External fault and internal fault current are sampled and processed to obtain wavelet coefficients. Different Operating conditions provide variation in wavelet coefficients. Features like energy and Standard deviation are calculated using Parsevals theorem. The fault detection algorithm is constructed on the basis of coefficient comparison from signals decomposed from Discrete Wavelet Transform. Computer simulations are performed using ATP/EMTP as well as MATLAB/Simulink. Various cases and fault types are studied to verify the validity of the algorithm. It is found that the proposed method gives a satisfactory accuracy, and will be particularly useful in a development of a modern differential relay for a transformer protection scheme.

KEYWORDS: Power Transformer, Wavelet Transform, Transactions on Power Systems

INTRODUCTION

In the power system Power transformer is one of the most essential elements. To connect two different voltage levels power transformer functions as a node. In maintaining the reliability of power system the continuity of the transformer operation is of vital importance. Any unscheduled maintenance, especially replacement of faulty transformer is very expensive and time consuming. Reliable protective relays are required to detect faults, high speed, highly sensitive and reliable protective relays are required. For this purpose, differential protection has been employed as the primary protection for most of the power transformers. Differential protection is based on the fact that any fault within electrical equipment may cause the current entering it, to be different from that leaving it. Thus, we can compare the two currents either in phase or in magnitude or both and issue a trip output if the difference crosses a predetermined set value. When both the ends of the apparatus are physically near each other this method becomes very attractive. A differential scheme is supposed to respond only to internal faults and restrain from tripping on inrush currents and external faults. The differential current is small for external and normal operating conditions differential current becomes significant for internal faults; the relay operates if the difference exceeds a Predetermined set value. To extract information from the transient signals simultaneously in both the time and frequency domain sun like Fourier Transform which can only give the information in the frequency domain The wavelet transform which is a new and powerful tool. For distinguishing internal fault currents from inrush currents wavelet transforms have been extensively used for analyzing the transient phenomena in a Power transformer [1]

WAVELET TRANSFORM FOR DETECTION OF FAULTS

Wavelet transform (WT) is an efficient and powerful technique to provide time frequency representation of a non stationary signal with good time resolution than a Fourier transform. It is an extension to short time Fourier transforms (STFT) which has constant window length. WT allows high frequency components to be analyzed with low frequency components to be analyzed with long time intervals and short time interval. To study and classify impulse faults in a transformer winding, wavelets have been widely used [4]. They have been also widely used to assess the mechanical integrity of transformer windings [5].

Effective usage in classification problems can be done as it has frequency selective feature. The continuous wavelet transform of a signal x (t), as given in [6] is

$$W_x(a, b)=1/\sqrt{a}\,\square\, x(t)\Psi((t-b)/a)\, dt$$

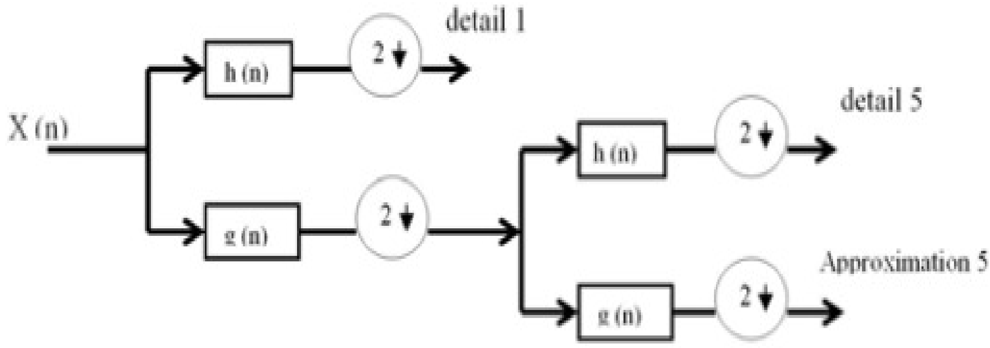

Figure 1: Decomposed Levels of DWT

Where Ψ is the basis function or the mother wavelet, 'a' and 'b' are the dilation and translation parameters respectively. The wavelet transform is evaluated at discrete scales as the computation of continuous wavelet transform generates good redundant data, and is known as discrete wavelet transform (DWT).

Detection of Ground Fault

As in the last case, the detection of ground fault proceeds in the same manner. The neutral current records corresponding to ground fault condition which are computed by Pspice software are wavelet transformed for analysis. For different ground faults the detail signals are at levels 5 to 8. With this observation we can say that it is possible to detect various ground faults effectively. The RMS values of the detail coefficients at levels 5 to 8 are computed and considered as the inputs to an artificial neural network, in order to automate the detection and classification task

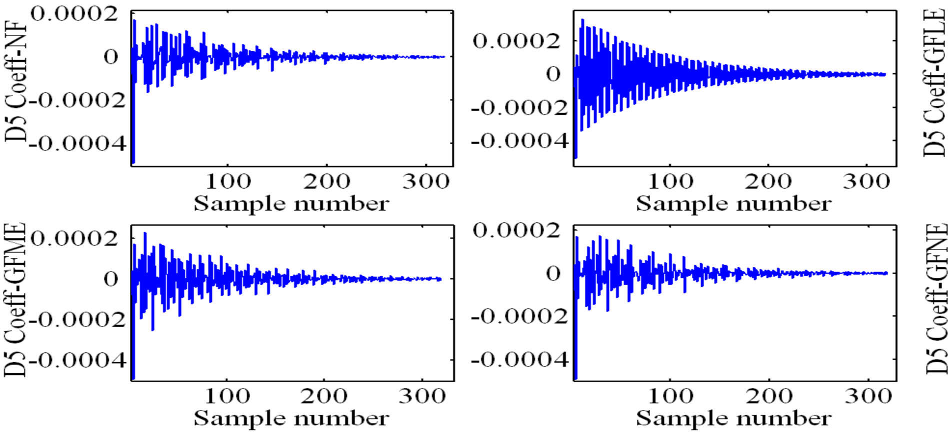

Figure 2: Wavelets Coefficients

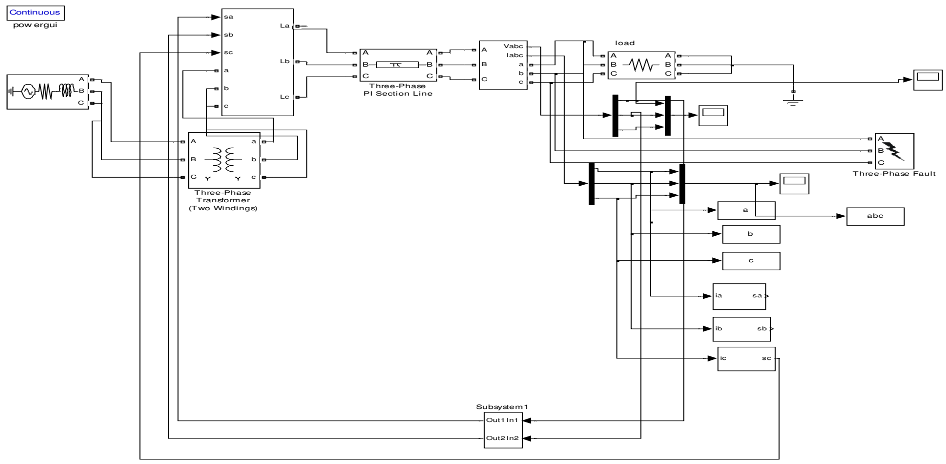

Figure 3: Simulation Model with Fault Detection

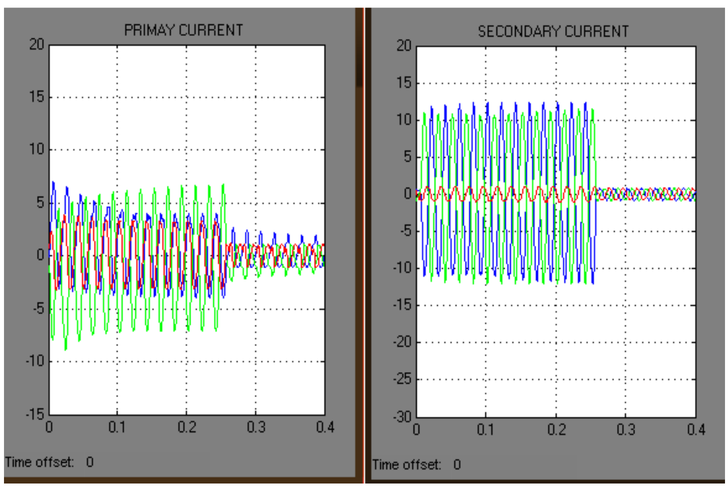

Figure 4: Primary Currents and Secondary Currents for Fault

PROPOSED ALGORITHM USING WAVELET TRANSFORM

MATLAB environment is chosen for them proposed protection algorithm. Referring to the relay flow chart shown as in figure 2, the program developed, receives sampled current data of the simulated faults from the power system Step.1 Using CTS and 800 samples of differential current, obtain three phase differential currents. Step.2 For sampling the differential current apply the wavelet transform for samples. Step.3 Using Parsevals theorem, energy and STD is obtained from approximation and details. This is used to obtain energy vector for tripping operation energy vectors calculated as Energy vector = Ed1 + Ed2 + Ed3 + Ed4 + Ed5 + A5

Table 1: Energy and Standard Deviation Values for Different Operating Conditions

Inrush Fault	WITHOUT LOAD				WITH LOAD			
	Training Data		Testing Data		Training Data		Testing Data	
	Energy	STD	Energy	STD	Energy	STD	Energy	STD
Normal	0.1339	0.0020	8.5488	0.0136	585.28	0.1504	595.70	0.1425
Inrush a	597.55	0.1427	0.1438	0.0024	480.31	0.1337	595.70	0.1252
Inrush B	594.32	0.1427	0.1299	0.0025	699.53	0.2011	493.93	0.1937
Inrush C	592.25	0.1431	0.1399	0.0023	1214.4	0.2690	1219.7	0.2603

CONCLUSIONS

This paper demonstrates that the algorithm successfully differentiates between fault conditions and magnetizing inrush and even if the faults occur with high impedance at fault location. With Daub 6 wavelet transforms, very accurate and satisfactory results obtained are due to the following factors: In both time and frequency, the wavelet decomposition breaks up the signals allowing for a more complete efficient and description of each phase currents and accurate fault detection than comparing to Fast Fourier algorithm. Since this method is used for discontinuity analysis of the signals, with high impedance at the fault location, the fault occurs at the lowest time space detail coefficients of the signal give us faulty condition. This work is based on recorded’ data, which was obtained from ATP-EMTP. For a future work, a real time digital signal processor can be used for analyzing current and voltage samples.

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