Dq0-DWT Based Analysis of Inrush and Fault Currents in Power Transformers

K .Omkar, M. V. Srikanth and K. P. Swaroop
Assistant Professor[1], Assistant Professor[2] , Assistant Professor[3]
Dept. Of EEE, SVECW, Bhimavaram
Kodurieee@gmail.com[1], srikanthmv@svecw.edu.in[2] , swaroopkp@svecw.edu.in

Abstract

This paper introduces dq0-Discreate wavelet analysis of inrush and fault current in power transformer. The proposed analysis is based on extracting high frequency sub-band contents present in the d-q axis components of the differential currents in order to analyze inrush and fault currents. The wavelet transform has the characteristic of multi-scale analysis and good time and frequency domain localization, fits to extract sudden-change signals in transient processes, and detects irregularity of signals very well. This paper analyzes the mechanism of transformer generating excitation inrush, and establishes simulation models of transformer inrush and internal fault. According to different characteristic between inrush and internal fault, choose a proper kind of wavelet to analyze waveforms of inrush and fault current.

***Keywords**: Power Transformer, dqo Transform, Inrush Current, fault Current, DWT, Db4*

I. INTRODUCTION

Power transformers are important equipment in the power system and its protection scheme is of vital significance to provide continuous power supply ensuring reliable operation. When the power transformer is switched ON, the remnant flux in the transformer draws the large current from the source this current is usually ten times that of the full load current. It persists only for a very short duration and decays very quickly, which is very high magnitude causes the relay to operate falsely. Hence, such inrush current needs to be discriminated from the internal fault to prevent mal operation. In conventional techniques like Second Harmonic restraint are used to discriminate inrush and fault [1].Some time internal fault have second harmonic content due to CT saturation [2].for the above mention problems. Neural and fuzzy logic techniques are used to detect the internal fault .In first approach differential harmonics were are used to train the neural network ,which requires the large tiring data and time consuming [3,4].In another approach fuzzy logic technique has been proposed[5,6] the method require new rules for every cases and threshold values is varying with respect to very case .To overcome the above limitations wavelet Transform is required .In this paper we propose the Discrete Wavelet Transform .Wavelet Transform has been used for analyzing Power system Transients[7].In [8,9] used Discrete Wavelet Transform for Differential Protection .In another approach [10] wavelet packet algorithm are used to extract certain features. In [11] S transform based differential protection is proposed.

In This paper to analyze the inrush and fault current by combining the dq0-DWT transform .Initially DWT transform applied to decompose the dq0 differential currents signals in to series of coefficients .DB1, DB2, DB3 and DB4 has been used for mother wavelet functions. Results are carried out in MATLAB/SIMULINK software.

II. PROPOSED METHOD

abc to dq0 Transformation:

The abc_to_dq0 Transformation computes the direct axis, quadratic axis, and zero sequence quantities in a two-axis rotating reference frame for a three-phase sinusoidal signal. The following transformation is used:

$$Vd= 2/3 \left(Va \cos(wt) +Vb \cos(wt-2\Pi/3)+ Vc \cos(wt+2\Pi/3) \right) \quad (1)$$

$$Vq= 2/3 \left(Va \sin(wt) +Vb \sin(wt-2\Pi/3)+ Vc \sin(wt+2\Pi/3) \right) \quad (2)$$

$$V0=1/3(Va+Vb+Vc) \quad (3)$$

Where ω = rotation speed (rad/s)

The transformation is the same for the case of a three-phase current; you simply replace the V_a, V_b, V_c, V_d, V_q and V_0 variables with the I_a, I_b, I_c, I_d, I_q, and I_0 variables.

Transient Analysis Based On Wavelet Transform:

Wavelet transform is a powerful signal processing tool used in power system analysis Wavelet transform is a powerful signal processing tool used in power system analysis localization of different frequency components of a given

Signal, however with one important difference STFT uses a fixed width windowing function. As result, both frequency and time resolution of the resulting transform will be a prior fixed but in the case of wavelet transform, the analyzing functions, which are called wavelet, will adjust their time widths to their frequency in such a way that, higher frequency wavelets will be very narrow and lower frequency wavelets will be wide. It been found using wavelet for the proposed power system it shows for internal fault currents window is narrow for inrush, current window is very wide. It can be defined as follows:

$$f(x) = \sum \Psi i,j\ (x) \quad (4)$$

Where i and j are integers, the functions $\Psi i,j(x)$ are the wavelet expansion functions and the two parameters expansion coefficients ai,j are called the discrete wavelet transform (DWT) coefficients of f(x The coefficients are given by

$$ai,j = \int_{-\infty}^{+\infty} f(x)\ \Psi i,j\ (x) \quad (5)$$

The wavelet basis functions can be computed from a function $\Psi i,j(x)$ called the generating or mother wavelet through translation and scaling (dilation) parameters

$$\Psi i,j\ (x) = 2^{-i/2}\ \Psi(2^{-i}\ x - j) \quad (6)$$

Where j is the translation parameter and i is the scaling parameters. Mother wavelet function is not unique, but it must satisfy a small set of conditions. One of them is Multi resolution condition and related to the two-scale difference equation

$$\varphi(x) = \surd 2 \sum_{k} h(k)\ \varphi(2x - k) \quad (7)$$

Where $\varphi(x)$ is scaling and $h(k)$ must satisfy several conditions to make basis wavelet functions unique, ortho normal and have a certain degree of regularity. The mother wavelet is related to the scaling function as follows:

$$\Psi(x) = \surd 2 \sum_{k} g(k)\ \varphi(2x - k) \quad (8)$$

Where $g(k) = (-1)^k h(1 - k)$. At this point, if valid $h(x)$ is available, one can obtain $g(x)$. Note that h and g can be viewed as filter coefficients of half band low-pass and high pass filters, respectively. J-level wavelet decomposition can compute with (9) as follows:

$$f0(x) = \sum a_{0,k}\ \varphi_{0,\ k}(k) = \sum a_{j+1\ ,k}\ \varphi_{j+1} + \sum_{j=0} d_{j+1\ ,k}\ \Psi_{j+1}\ ,k(x) \quad (9)$$

Where coefficients $a0,\ k$ and coefficients $aj+1,\ n$ and $dj+1,\ n$

At scale $j + 1$ are given

Multi resolution analysis leads to a hierarchical and fast scheme. This can be implemented by a set of successive filter banks. Fig.1 illustrates the implementation procedure for discrete wavelet transform in which $X(n)$ is the original signal, $h(n)$ and $g(n)$ are low pass filter and high pass filter respectively. At the first stage, an original signal is divided

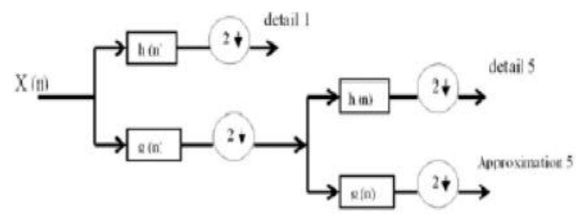

Fig. 1. Decomposed levels of DWT

in to two halves of the frequency bandwidth and sent to both HPF and LPF then the output of the LPF is further cut in half of the frequency bandwidth and sent to the second stage, this procedure is repeated until the signal is decomposed to a predefined certain level.

In this paper, transformer different operating conditions are decomposed to four levels; a5 is the approximation level containing the fundamental frequency component and d1 to d6 are detail levels with high frequencies. The sixth order Daubechies (db6) wavelet filter was used for wavelet decomposition.

III SYSTEM STUDIED

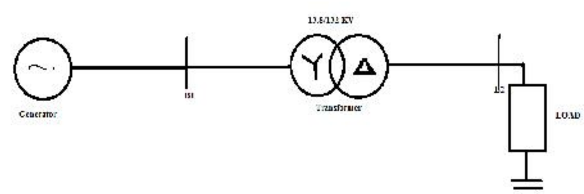

Fig. 2: Simulated System

400 kV transmission line with power transformer and load as shown in fig 2 has been taken as to analyze the internal and inrush fault conditions. The system has been simulated using the simulink model available in the MATLAB power system toolbox. The transmission line length is 225 Km.

IV) SIMULATION RESULTS

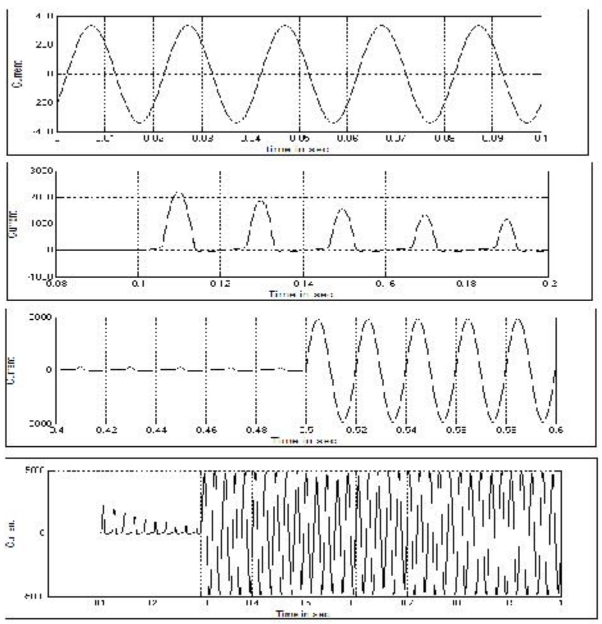

Fig. 3: Actual signals of power transformer during normal condition, inrush, fault condition.

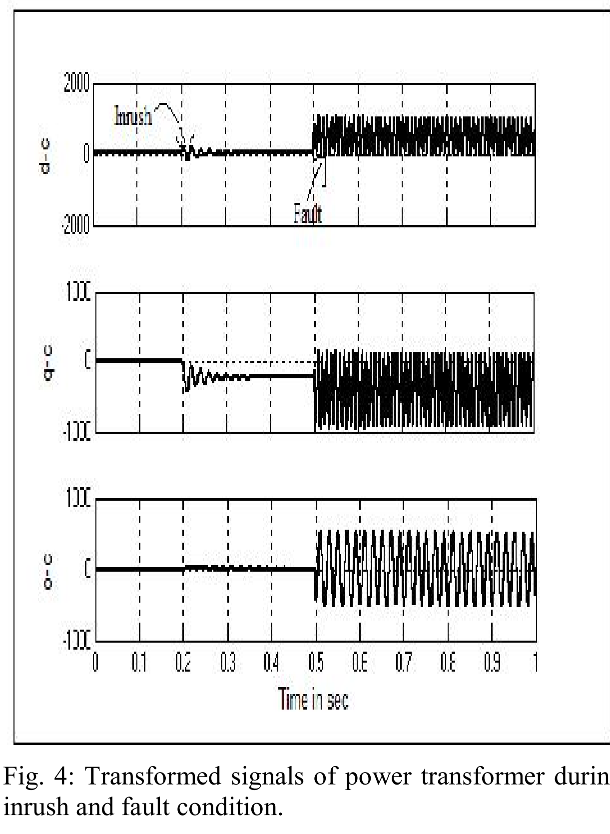

Fig. 4: Transformed signals of power transformer during inrush and fault condition.

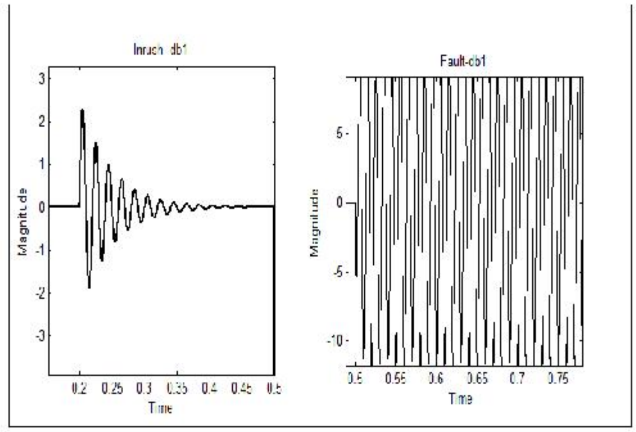

Fig. 5: DB1 Coefficients of inrush and fault of Power Transformer

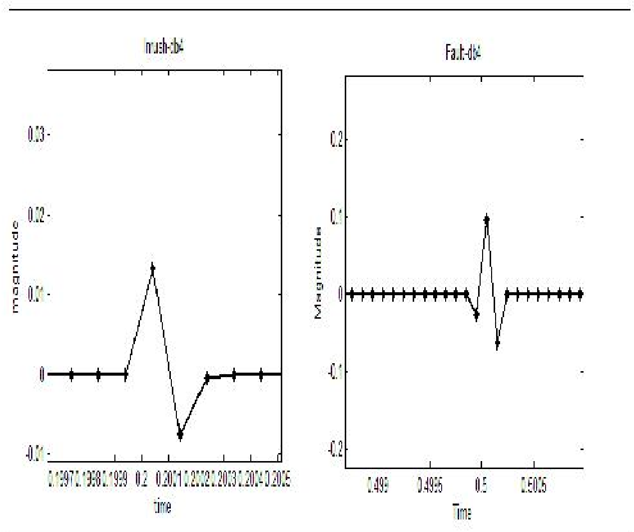

Fig 6: DB4 Coefficients of inrush and faul of Power Transformer

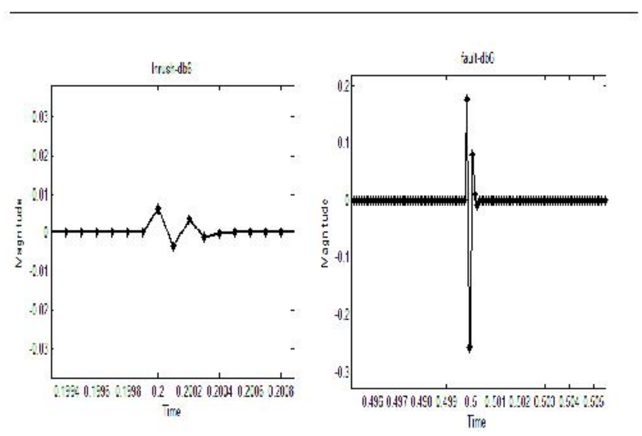

Fig 7: DB6 Coefficients of inrush and fault of Power Transformer

Type of coefficient	Inrush current		Fault current	
Db 1	0.0412	-0.4167	8.3634	-10.841
	0.1216	-0.4786	7.9822	1
	0.2016	-0.5398	7.5570	-9.0032
	0.2809	-0.6002	7.0902	-7.2636
	1.1624	-0.6597	6.5848	-5.6202
	1.2280	-0.7183	6.0434	-4.0711
	1.2921	-0.7760	5.4691	-2.6143
	1.3547	-0.8327	4.8647	-1.2482
				-0.0290
Db 2	0.0317	-0.0107	0.7896	-0.3074
	0.0312	-0.0116	0.7472	-0.3013
	0.0307	-0.0124	0.7056	-0.2940
	0.0301	-0.0133	0.6649	-0.2855
	0.0295	-0.0141	0.6250	-0.2759
	0.0289	-0.0149	0.5859	-0.2650
	0.0283	-0.0157	0.5475	-0.2531
	0.0277	-0.0165	0.5098	-0.2402
Db 3	0.0003	-0.0002	0.0089	-0.0189
	0.0004	-0.0002	0.0091	-0.0186
	0.0004	-0.0002	0.0092	-0.0182
	0.0004	-0.0002	0.0093	-0.0178
	0.0004	-0.0003	0.0094	-0.0175
	0.0004	-0.0003	0.0094	-0.0172
	0.0004	-0.0003	0.0094	-0.0169
	0.0004	-0.0003	0.0093	-0.0166
Db 4	0.0132	-0.0076	0.4075	0.0002
	0.0000	-0.0006	0.1919	-0.0002
	0.0000	-0.0000	0.5642	-0.0002
	0.0000	-0.0000	0.0002	-0.0003
	0.0000	-0.0000	0.0002	-0.0003
	0.0000	-0.0000	0.0001	-0.0003
	0.0000	-0.0000	0.0001	-0.0003
	0.0000	-0.0000	0.0001	-0.0002

Table-1. The detailed analysis of DWT values for different faults.

CONCLUSION

A dq0-dwt based Analysis of inrush and fault currents in power transformer are presented and it is simulated with Different type of faults. We transform the signals to dq0 and applied Daubechies DB1, 2,3,4,5 &6 wavelets and observe the different db coefficients of inrush and fault current.

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M.V Srikanth: He did M.Tech from J.N.T U Anathapur in 2010 .He research interest is Control system and power systems. He has 10 Conference papers and 5 papers in various journals.

K.P Swaroop: He did M.Tech from J.N.T U Hyderabad in 2008.He research interest is Power system operation and control .He has 8 conference papers and 4 papers in various journals.