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# STUDY OF TRANSIENT PHENOMENA IN POWER TRANSFORMER USING WAVELETS AND ANN ALGORITHM

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## Abstract

*The role of power transformer protective relay is to rapidly operate the tripping during fault conditions and block the tripping during other operating conditions of power transformer. This paper presents a new approach for classifying transient phenomena in power transformers, which may be implemented in digital relaying for transformer differential protection. Discrimination among different operating conditions (inrush, external fault) of the power transformer is achieved by combining wavelet transform with neural network. The simulation results obtained shows that the new algorithm accurately provides high operating sensitivity for internal faults and remain stable for other operating conditions of the power transformer. Different wavelets are applied for coiflet, Daubichies, symlet and haar wavelet.*

***Index Terms— inrush current, fault current, wavelets, ANN***

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## 1. INTRODUCTION

Power transformer is one of the most important classes of hardware in electric power systems, and the transformer protection is an essential part of the overall system protection strategy. The design of protective relay has to consider various nonlinear effects, which may cause malfunctioning of the relay equipments. The most common method of transformer protection utilizes the percentage differential relay as the primary protection. Discrimination between an internal fault and other operating conditions such as magnetizing inrush current, over excitation, CT saturation is recognized as challenging power transformer protection problem. The conventional technique based on transient detection was developed for accurate and efficient discrimination. Recently ANN techniques have been applied for power transformer protection because of its capability of highly non-linear mapping feature. But in these proposed methods the extraction techniques are based on either time or frequency domain signals, but it becomes very important to extract both time and frequency features of the signal for accurate discrimination between an internal fault and other operating conditions. Moreover to improve system performance is chosen for analyzing power transformer transients because of its good ability to extract information from the transient signals in terms of both time and frequency domain.

The wavelet transform is relevantly new and powerful tool in analyzing of power transformer transient phenomena because of its ability to acquire information from the transient signals both in time and frequency domain. Recently wavelet transform have been applied to analyze the power system transient as well as fault location and fault detection problems. Wavelet transform and ANN was successfully applied in power systems applications, especially in discrimination of the different transient phenomena in power transformer.

The technique is to discriminate between an internal fault and other operating conditions of the power transformer by combining wavelet transform with neural network. In this proposed method, the wavelet transform is firstly applied to decompose the differential current signals of power transformer.

## 2. METHODOLOGY

One of the major Signal Processing tools is the Fourier analysis, which has different forms like Fourier series, Fourier Transform, Discrete Fourier Transform, and so on. Fourier analysis methods use orthogonal sets of functions in order to expand a given periodic function into an infinite series. While a large number of orthogonal sets exist, the Fourier analysis form which is commonly utilized makes use of the cosine and sine functions. However, for non-periodic time-varying signals, the above mentioned method has several inconveniences. To a certain extent, these could be overcome by the application of different windowing techniques leading to the short-time-Fourier Transforms. But these have also their own limitations. An alternative method is to use wavelets.

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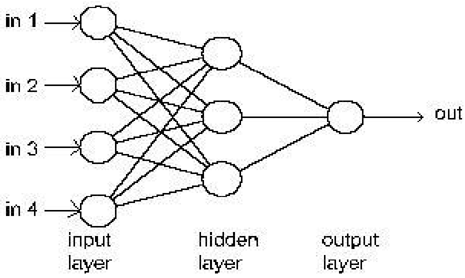
## 3. DATA FOR TRAINING AND TESTING OF ANN ARCHITECTURE:

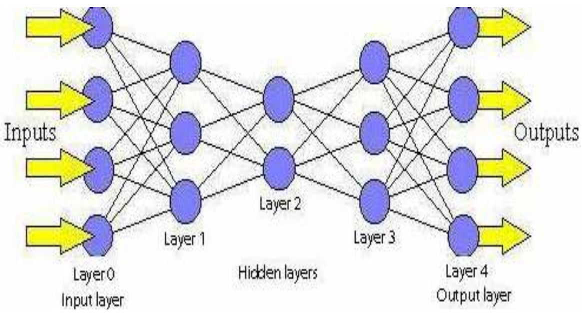
The network has been trained to distinguish two kinds of signals (Inrush, external fault). The rating of power transformer selected for simulation is 31.5 MVA 110/11 KV. The Inrush currents and external fault currents like L-G fault, L-L fault and $3-\Phi$ fault at different breaker timings in a power transformer are obtained by using MATLAB / SIMULINK. After decomposing these signal using DB2 and level 5, the obtained standard deviations of the detailed coefficient at level 1(D1) are given as inputs for training the neural network. Ten different breaker timing are taken for which the simulation is made. One standard deviation coefficient per phase is obtained for each for different timings of breaker. For all the ten breaker timings there are 10 standard deviation coefficients per phase. Totally there are 30 standard deviation coefficients. Similarly 30 standard deviation coefficients each are available for the external faults. These standard deviation data that is available by decomposition of the signal using wavelets are used as inputs to train the neural network. The output of the ANN architecture is having two outputs that is '0' for Inrush current and '1' for the external fault

### 3.1. ANN architecture:



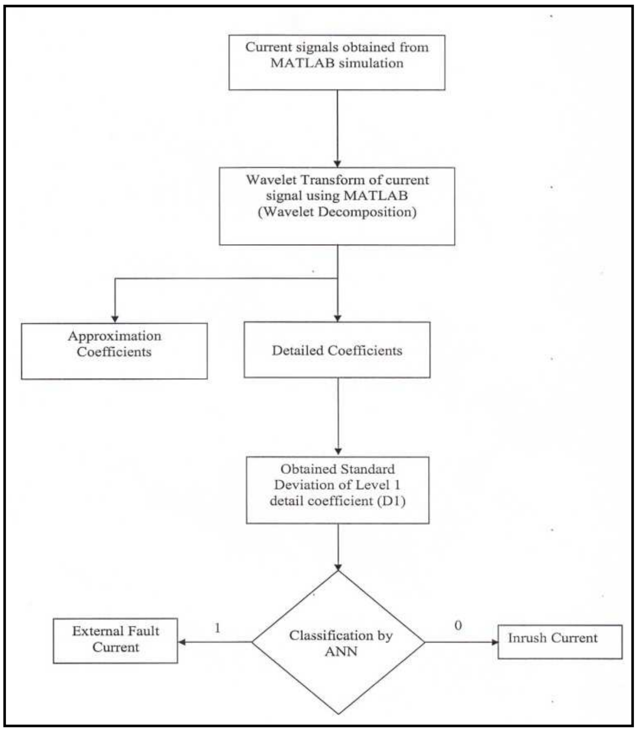

Architecture of ANN

## 4. PROPOSED METHOD USING ANN:




Feed-forward network

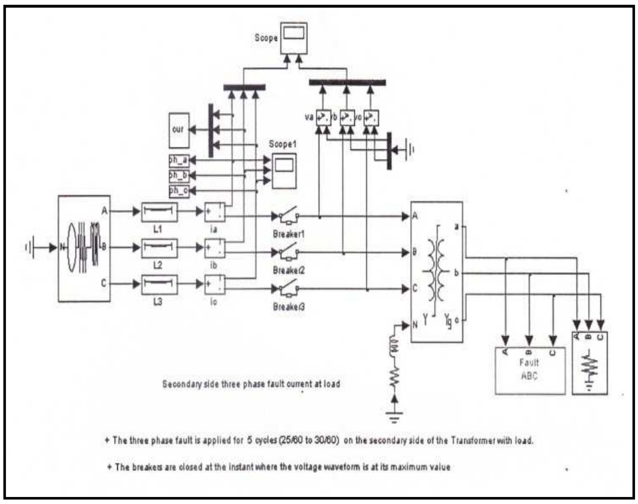
## 5. FLOW-CHART




Algorithm of the proposed scheme

## 6. CIRCUIT DESCRIPTION & ANALYSIS

*$3-\Phi$ FAULT:*




*$3-\Phi$ Fault current analysis*

## 7. CIRCUIT DESCRIPTION:

The each phase of the voltage source is connected to its distributed parameter branch. The output of the distributed parameter is connected to its $1-\Phi$ CB through current measurement branch, from which we can measure the Inrush or fault current in the line. The individual circuit breaker output is connected to the primary of the $3\Phi$ power transformer of concern phase. The secondary of the transformer is loaded with resistive load as in the case of L-L fault. The $3-\Phi$ fault is applied on the secondary of the transformer.

## 8. CIRCUIT OPERATION FOR L-L FAULT CURRENT:

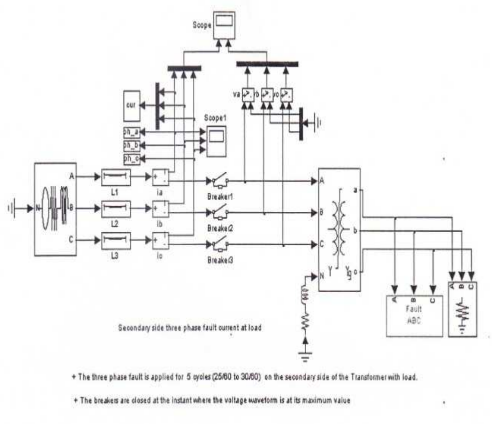
All the three circuit breakers are not closed at the same instant rather they are closed when the respective voltage waveforms are taking their maximum value in order to minimize the inrush effect. The $3-\Phi$ fault is applied for 5 cycles i.e. from 25/60 cycles to 30/60 cycles.

The CB's are closed at their first switching timings. For the first switching timing 3.25/60 (phase A) the energy source is now connected to the power transformer through CB's. Now a $3-\Phi$ fault is applied. From the current measurement, currents through all the three lines are tapped to MATLAB work space. The data in the workspace decomposed to Detail coefficients and Approximation coefficients using the wavelet tool box (>> help *wavemenu*). The decomposition is done by using four different mother wavelets viz Daubichies wavelet (bd2), Haar wavelet (haar), Symlet wavelet (sym 2), Coiflet wavelet (coif 2). The decomposition is done at level 5. The standard deviation of the detailed coefficient (D1) at level 1 is taken for the given switching timing for all the three phases.

The circuit breakers are operated for new switching timing i.e. 5.25/60 and the same procedure is repeated for the new switching timing. This procedure is continued for all the switching timings. This standard deviation date is given as input to the ANN program for further analysis.

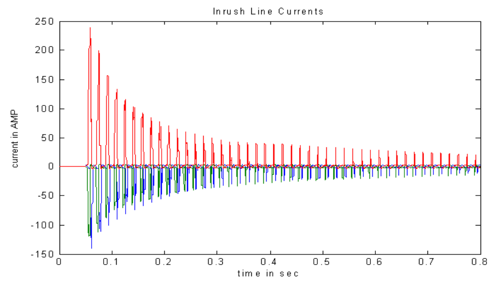
## 9. CIRCUIT DIAGRAMS

*$3-\Phi$ fault:*



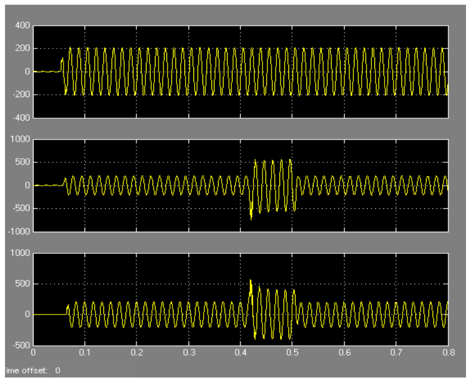

$3-\varphi$ fault current analysis

### 9.1. Inrush current in the circuit:



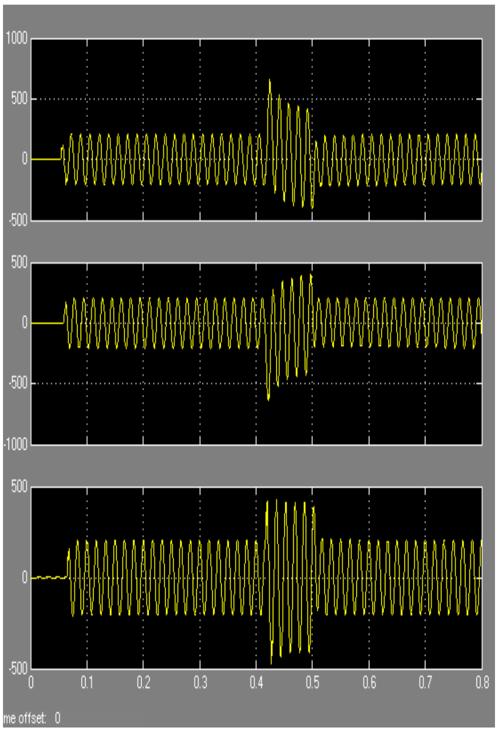

Inrush current in the lines (all the three phases)

### 9.2. Fault current diagrams:



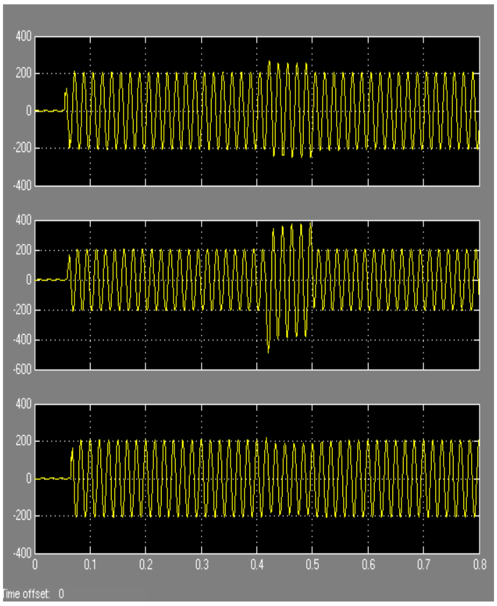
Waveforms for line to line fault (fault on phase b & c)

$3-\Phi$ Fault on the system:



Waveforms for $3-\Phi$ fault

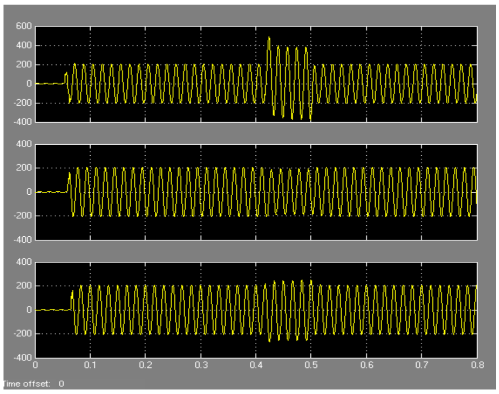
### 9.3. Line to ground fault (fault on phase b)



Wave forms for line to ground fault (fault on phase B)

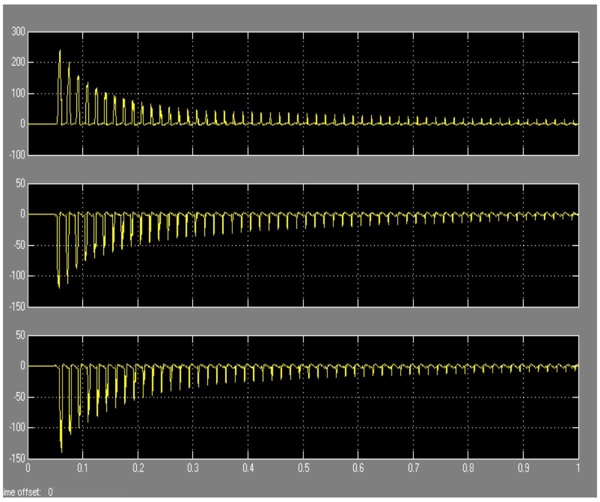
| Breaker closing timings | Phase A | Phase B | Phase C |
|---|---|---|---|
| 3.25/60,(3.25+1/3)/60,(3.25+2/3)/60 | 1.661 | 1.701 | 1.709 |
| 5.25/60,(5.25+1/3)/60,(5.25+2/3)/60 | 1.660 | 1.709 | 1.636 |
| 7.25/60,(7.25+1/3)/60,(7.25+2/3)/60 | 1.532 | 1.839 | 1.748 |
| 9.25/60,(9.25+1/3)/60,(9.25+2/3)/60 | 1.658 | 1.714 | 1.679 |
| 11.25/60,(11.25+1/3)/60,(11.25+2/3)/60 | 1.617 | 1.730 | 1.697 |
| 13.25/60,(13.25+1/3)/60,(13.25+2/3)/60 | 1.513 | 1.744<br>0 | 1.720<br>0 |
| 15.25/60,(15.25+1/3)/60,(15.25+2/3)/60 | 1.506<br>0 | 1.702<br>0 | 1.587<br>0 |
| 17.25/60,(17.25+1/3)/60,(17.25+2/3)/60 | 1.500<br>0 | 1.655<br>0 | 1.616<br>0 |
| 19.25/60,(19.25+1/3)/60,(19.25+2/3)/60 | 1.480<br>0 | 1.541<br>0 | 1.616<br>0 |
| 21.25/60,(21.25+1/3)/60,(21.25+2/3)/60 | 1.397<br>0 | 1.496<br>0 | 1.502<br>0 |

## 10. LINE TO GROUND FAULT (FAULT ON PHASE A)



Waveforms for line to ground fault (fault on phase A)

## INRUSH CURRENT:



Waveforms forms for inrush current

## Data for ANN (standard deviations)

| Breaker closing timings | Phase A | Phase B | Phase C |
|---|---|---|---|
| 3/60,3/60,3/60 | 0.3717 | 0.3012 | 0.2736 |
| 5/60,5/60,5/60 | 0.4180 | 0.3016 | 0.2654 |
| 7/60,7/60,7/60 | 0.4170 | 0.3135 | 0.2867 |
| 9/60,9/60,9/60 | 0.3977 | 0.2861 | 0.2656 |
| 11/60,11/60,11/60 | 0.3967 | 0.3339 | 0.2999 |
| 13/60,13/60,13/60 | 0.3981 | 0.3279 | 0.2865 |
| 15/60,15/60,15/60 | 0.4027 | 0.3197 | 0.3037 |
| 17/60,17/60,17/60 | 0.4154 | 0.2572 | 0.2974 |
| 19/60,19/60,19/60 | 0.3970 | 0.2980 | 0.2896 |
| 21/60,21/60,21/60 | 0.4113 | 0.2848 | 0.2827 |

The standard deviation of detail coefficients of inrush current ($1^{st}$ level D1) (db2)

The standard deviation of detail coefficients of 3-$\phi$ fault ($1^{st}$ level) (D1)

## CONCLUSION

❖ The wavelet decomposition divides the signals into time and frequency, allowing for a more complete and efficient description of each phase current and exact fault detection.

❖ The proposed circuit uses wavelet transform with neural network for discriminating inrush current and the fault currents in a power transformer.

❖ Present method is used for discontinuity analysis of the signals, even if the fault occurs at the less time period with high impedance at the fault location, detail coefficients of the signal reveals the faulty condition.

❖ The proposed method proves to be efficient method for discriminating transformer currents.

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## BIOGRAPHIES

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