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A Study Of Wavelet Based Intelligence Technique For The Protection Of Transformer

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Abstract— A new scheme to enhance the solution for the problems associated with protection of power transformer, power system components is presented in this work. Power Transformer, which needs a continuous monitoring of its health so that the system performs efficiently.This work demonstrates a novel application of continuous wavelet transform to identify internal faults and magnetizing inrush currents in power system components and the transformer protection is developed based on Artificial Neural Network (ANN) and Wavelet transform (WT), which proved to provide much satisfactory performance of the equipment. The various transients created during the operation of the transformer is facilitated for detailed analysis by the use of wavelet transform method in time domain and the frequency domain.

Keywords—**Power transformer, Wavelet Transforms, ANN, Internal Fault, Magnetizing inrush current.**

1. INTRODUCTION

Of all the equipment in the power system, transformer protection is in priority as it is in continuous service, apart from it being the most expensive equipment. Generally, differential protection is used for large MVA rating transformer. Development of laboratory prototype of transformer differential protection scheme is extremely challenging due to various abnormal/operating conditions which affect its performance. The operation of the transformer can be broadly classified into five different categories such as (i) no-load condition (ii) full-load condition (iii) external fault (iv)magnetizing inrush condition and (v) internal fault. For the first four operating conditions, the relay should not operate, but for any internal fault condition, it must operate instantaneously. To provide high sensitivity on internal faults having a lower magnitude of current and high security on external faults, most differential relays are of the percentage differential type in which transient magnetizing inrush and internal fault must be distinguished. In the last decade various power system protection laboratory has been described in the literature. Moreover, due to improvement in core steel material, the percentage of the second harmonic component present in magnetizing inrush is reduced. Thus, the traditional method of harmonic restrained differential protection provided by digital relays malfunctions due to the less amount of the second harmonic in magnetizing inrush and higher amount of the second harmonic in case of internal faults. In this paper, Artificial Neural Network (ANN) has been utilized as a classification tool which can effectively classify the internal faults with various types of other external disturbances in power transformer. This tool can provide additional security for un-intended operations of differential relays of the power transformer. The differential relays based on ANN and Wavelet Transform technique gave accurate results between simulation and real time study when applied to transformers unbiased of the transformer parameters, loads, earthing conditions etc.The suggested technique has realized with Minimum the optimum rate of classification for the monitoring of the transformer faults for inrush and internal faults.

II. WAVELET TRANSFORM

Transients in a Power system are initiated every time whenever there is a change of system operational conditions these can be analyzed using Wavelet transform. Extensive research shows that transients of a power system, especially those generated by a fault, are very rich in operational information of a power system. So, wavelet analysis is suitable for transient signal analysis as measured by protective relays. so, wavelet analysis is suitable for transient signal analysis as measured by protective relays. The WT is an efficient signal processing tool used in power system analysis. The WT and STFT allow different frequency components to be time localized, with fixed window width function as in STFT. This results in prior determined frequency and time resolution. however the WT using wavelets as the analyzing function have a self-adjusting capability to the time widths in relation to frequency thereby creating a inversely related frequency / width wavelet, i.e greater frequency - narrow width and vice versa. Transients create higher frequency components and have shorter time intervals, in contrast to lower frequency

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components and higher time intervals. WT has the inherent advantage of focusing on shorter time intervals, thereby picking transients for analysis. for this reason, to study transient signals, for achieving reliable discrimination based on current characteristics, wavelet decomposition is ideal.

The continuous wavelet transform (CWT) decomposes the time series into time-frequency space, enabling the identification of dominant modes of variability in the measured response and how those modes can vary with respect to time. CWT of a discrete sequence Pn of the winding response (time series) P(t) sampled at equal time interval (Δt, n=1,2,...,N) is defined as the convolution of Pn with a scaled or dilated (s) and translated version of mother wavelet function (ψ) and it is given mathematically as

$$W_n^P(s) = \sum_{n'=0}^{N-1} P_n \psi^* \left[\frac{(n'-n)\Delta t}{s} \right] \qquad (1)$$

where, * indicates the complex conjugate of mother wavelet, n-n is the translation parameter. The wavelet analysis results for PD identification are related to choice of wavelet. Hence, Morlet wavelet is used in this paper to provide a good balance between time and frequency localization.

III. ARTIFICIAL NEURAL NETWORK

The harmonic restraint differential relay operates with a minimum delay of one cycle and moreover. In modern transformers, the level of the second harmonic component is reduced to a great extent. So, no longer internal faults and inrush currents are classified using harmonic restraint methods. ANN has proved to be very efficient in the field of classification. The differential current obtained from the ATP/EMTP simulation for various internal fault, inrush, and external fault, normal and over excitation operating conditions are fed to ANN and trained. In real time applications, the computers have to perform complex pattern recognition problems. Hence, the technology has come to be known as ANN. The ANN is an identical simulation of the functions of a human nervous system adapted for complex pattern-matching problems. A Neural network which takes in the input and conveys the processed information ahead of it is the feed Forward Neural Network. The passing of information is based on the connection strengths known as weights, and an appropriate selection of weights, it is possible to perform several pattern recognition tasks. The constraint on the number of input patterns is overcome by using a two layer nonlinear FFNN in the output layer. This modification automatically leads to the consideration of pattern classification problems. While this Modification overcomes the constraints of number and linear independence on the input patterns, it introduces the limitations of linear separability of the functional relation between input and output patterns. Hard classification problems are those which are beyond the capability of solution by linear methods and for such cases , a multilayer , feed forward network , comprising of non linear elements in all the layers , other than the input layer is proposed. While a multilayer feed forward architecture could solve representation of the hard problems in the network, it leads to a difficult situation in dealing with hard problems , in terms of weight adjustment. An ANN operates on basically two types of operation i.e training and testing. In training or learning mode, the network starts with an assumed values and trains, self, by suitable internal modification of the “guess” input such that the outputs are considered satisfactory. Adapting to the situation, the weights on the neurons are to obtain the optimum response. The NN learns in Supervised and Unsupervised Learning modes. As the desired performance is reached, the learning process stopped and this output can be used for future classification of inputs. For an accurate training and learning by the network, the outputs cannot deviate from the learning with similar inputs . The network designed and simulated in MATLAB/ SIMULINK is shown in Fig.

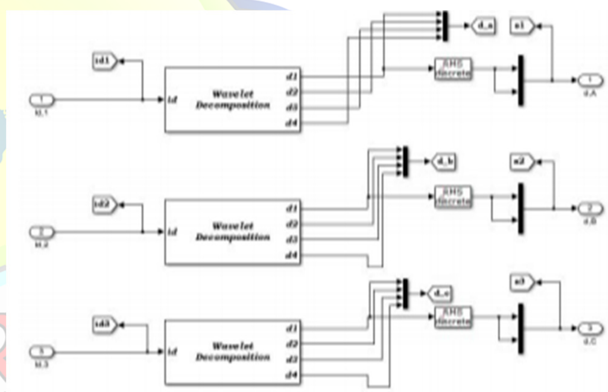

Fig.1 Wavelet with Artificial Neural Network

IV.ALGORITHM FOR ANN

The flowchart of the algorithm for ANN based relaying is explained in steps and the fig.2 shows the methodology used. In order to obtain the transient signals Alternative Transient Program (ATP) software is used.

Step 1.Indicates the resulting current and voltage waveforms for ATP/EMTP simulated different faults and no fault conditions.

Step 2: The difference between an output and input current for the various cases are calculated.

Step 3: The first 600 samples i.e., samples in one cycle, of the differential current after the occurrence of the fault or no fault condition are fed to ANN and trained. The output of the fault samples are assigned ‘1’ and the output of the no fault samples are assigned ‘0’.

Step 4: Next, the trained relay is tested with the cases which are not used for training

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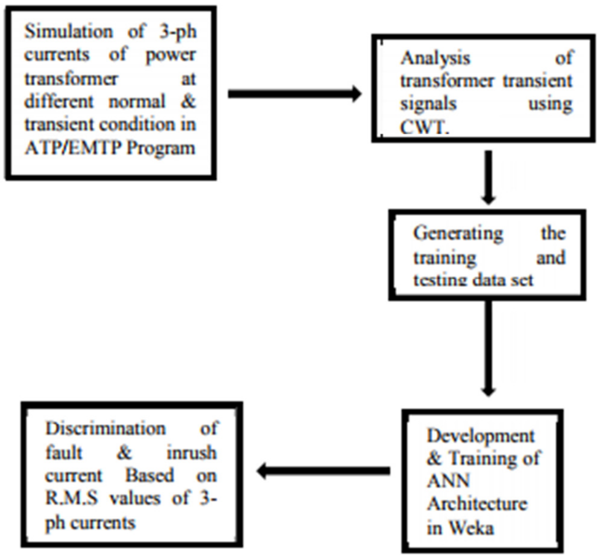

Fig. 2. Methodology

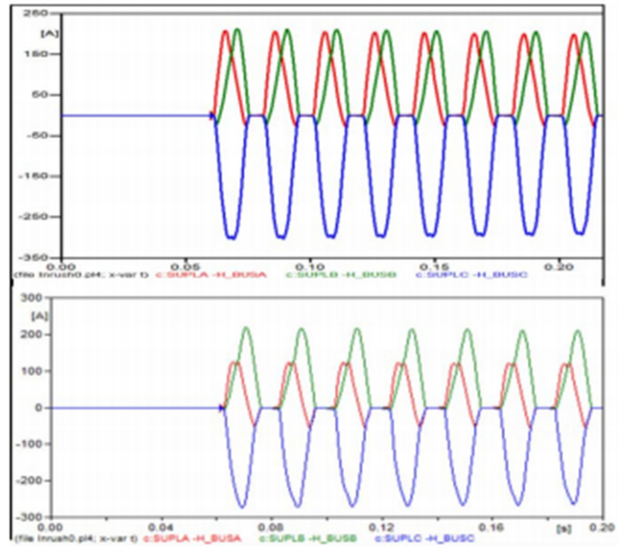

Fig.3. Inrush current signals extracted in ATP/EMTP

V.EXTRACTION OF INRUSH CURRENT SIGNALS

Inrush and internal fault signals extracted from simulations in ATP/EMTP for cases without fault, with LG, LLG, LLLG fault conditions. To obtain inrush condition, two time controlled switches are used. The purpose is to get the subsequent energization to obtain magnetizing inrush signals. The severity of the Simulation of 3-ph currents of power transformer at different normal & transient condition in ATP/EMTP Program Discrimination of fault & inrush current Based on R.M.S values of 3- ph currents Generating the training and testing data set Analysis of transformer transient signals using CWT, Development & Training of ANN Architecture in Weka and magnetizing inrush signal depends on the angle at which the power transformer has been switched on its source voltage form.

To analyze the performance of the proposed algorithm, extraction of inrush signals at different switching periods is also necessary. By adjusting the closing time of the second switch the magnetizing inrush signals at different switching periods have been extracted. In case of re-energization period the transformer core gets deep saturated, due to the residual flux remaining in the core. So, the power transformer draws very high (magnetizing inrush) current from the source which will flow only through the primary winding. The three phase inrush current signals of the unloaded power transformerobtained when switched at 0^0 and 18^0 have been shown in Fig.3 respectively. Similarly 3-phase primary and secondary current signals of Power transformer for LG, LLG, LLLG conditions with different fault resistance are extracted and the fig.4 shows the fault current extracted from ATP/EMTP.

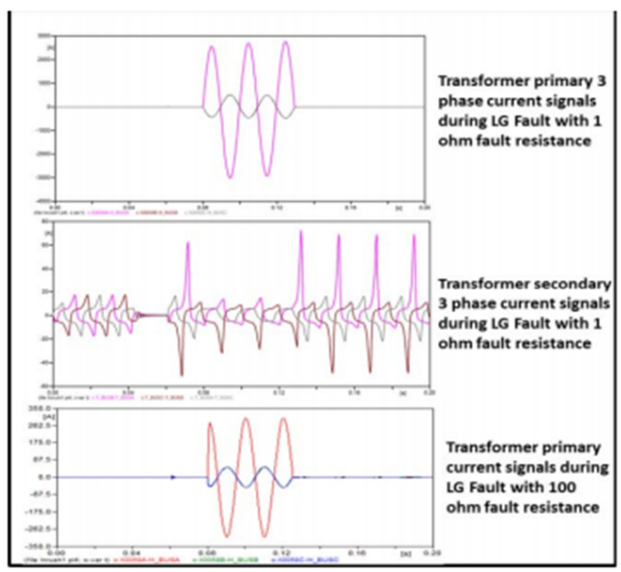

Fig.4. Fault current extracted from ATP /EMTP

VI. WAVELET ON PROTECTION OF TRANSFORMER

Wavelet analysis allows the use of long time intervals where more precise low-frequency information is required, and short regions where high frequency information is looked for. Wavelet algorithms process data at different scales or resolutions. Fig.5. CWT (db8) analysis Inrush and Internal fault current using MATLAB. The continuous wavelet transform (CWT) is defined as the sum over all time of the signal multiplied by scaled, shifted versions of the wavelet function. If scales and positions based on powers of two – so called dyadic scales and positions are chosen-then the analysis

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will much more efficient and accurate. So the original signal passes through two complementary filters and emerges as two signals termed as Approximation and Details in wavelet analysis.

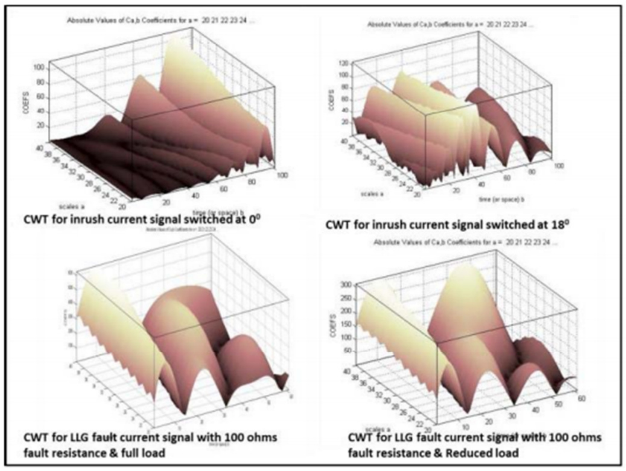

Fig.5.CWT analysis of Inrush and fault currents using MATLAB.

Almost 150 of CWT based samples are extracted, in which 6 attributes are present i.e. RMS values of coefficients of Wavelet transforms applied to three phase primary and secondary current signals of power transformer in inrush, LG, LLG, LLLG fault signals with different fault impedances and loading, extracted from ATP/EMTP. Out of the total samples 150, 100 samples are used for training and 50 samples for testing

It is very clear that the CWT coefficient of the faulty phases are greater when compared to the CWT coefficient of the inrush current. Unlike harmonic restraint differential relay which operates with a delay of one cycle, WT identifies LLG internal fault immediately.

VII. CONCLUSIONS

The ANN based WT is a new approach for diagnosing different types of fault currents for power transformer protection is developed. The different and unpredictable characteristics of magnetizing inrush currents did not appreciably affect the ability of the ANN based WT differential protective relay to diagnose them as non fault currents. The proposed scheme consists of a processing unit based on Wavelet Transform (WT) in combination with Artificial Neural Networks (ANN). For getting the accurate discrimination of the signals, various analysis have been carried out and from that important conclusions have been obtained. The presented results show that proposed CWT-ANN technique gives a very high accuracy in classification of the transient current signal and can be used as a good alternative for protection of large power transformers. The simulation results show fast, accurate and reliable capabilities of the ANN base WT to identify different types of currents flowing in a power transformer under various operating conditions.

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