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Wavelet and ANN Based Classification for Power Transformer Protection

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Abstract: -

Currently, the differential function has been widely used in transformer protection relay. However, the main issue of this technique is assigned to the relay mis operation during the presence of inrush currents and current transformer (CT) saturation. In the literature, these limitations have been overcome with the use of tools based on artificial intelligence and signal processing, such as the methods based on artificial neural networks and wavelet transform. This paper proposes a method based the ANNs and wavelet transform to detect and classify disturbance in the power transformer accurately. The algorithm uses wavelet based disturbance detector in order to detect any disturbance related to a power transformer, whereas a neural network based routine is used to classify the disturbance type (internal fault, external fault and transformer energization) appropriately, as well as to classify the internal faults. Several events were simulated, such as external and internal faults, with variations of fault resistance, fault inception angle, and fault type parameters, as well as transformer energizations. The method presented an excellent success rate regarding the correct classification of the disturbance as well as an accurate fault classification.

Index Terms—Artificial neural networks (ANNs), current transformer saturation, differential protection, power transformers.

I INTRODUCTION

Power transformer is one of the most important device in electrical power systems, since its operation is associated to the continuity of the electrical energy supply by interconnecting networks with different voltage levels. Faults in transformers are considered the most severe disturbances in transmission networks [1]. Therefore, a quick and accurate diagnosis of faults is very important and vital for the electrical power system. Among the power transformer protection schemes, the differential function has been used in relay largely. Basically, this function compares the currents that flow through the terminals of the protected transformer, so that in the occurrence of an internal fault, the equipment must be disconnected from the electrical system [2]. However, a great disadvantage of this technique is associated to the relay misoperation during inrush currents in the transformer energization maneuver or external fault clearance situations, as well as the presence of the distorted currents due to the current transformer (CT) saturation. In order to face these limitations, new techniques and methods based on artificial intelligence and signal processing have been applied for discriminating internal faults from other power transformer disturbances accurately [3], [4], [5]. Among these algorithms, the wavelet transform is an efficient tool for analysis of non-stationary signals at different levels of time frequency, which makes it widely applicable in the detection of electrical power system disturbances [6] [7], with applicability to the power transformer differential protection [8]. On the other hand, the characteristic of learning makes the artificial neural networks (ANN) able to solve many problems of pattern classification, such as fault classification in transmission lines [9], [10], [11].

II Literature

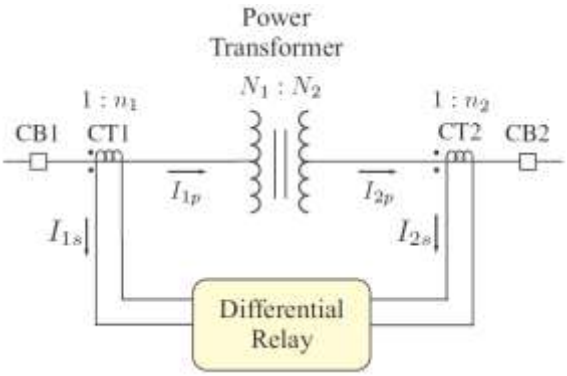
The differential protection used for transformers is based on the principle of current circulation. This type of protection is mostly used for transformers as this responds not only to inter turn fault but also provides protection In a power transformer, the currents in primary and secondary are to be compared As these two currents are usually different, therefore the use of identical transformers will give differential current and operate the relay even under no load conditions.[9]

Since Morlet first began to use wavelet analysis, it has been widely studied by many mathematicians, physicist, engineers, etc. today, its interest is spread out on not only theoretical but various applied fields, for example, speech or image signal processing, vibration analysis and so on. The wavelet analysis need not to use a single window function in all frequency components, or has linear resolution in the whole frequency domain that are weak points for Fourier analysis. There is enough reason that much interest concentrates on wavelet in time-frequency analysis [11].

The differential protection concepts are based on the assumption that during internal fault, the fundamental component of differential current becomes higher than no-load current. In this area several protection scheme have been developed to solve various difficulties (such as magnetizing inrush current) (6).

III DIFFERENTIAL PROTECTION

The differential protection relay compares the currents that flow through the power transformer windings. As an example, Fig. depicts a typical differential protection scheme for a single-phase two-winding power transformer, in which N1:N2 corresponds to the ratios of the power transformer, and 1 : n1 and 1 : n2 correspond, respectively, to the ratios of the current transformers (CT1 and CT2). The CT ratios are usually selected to satisfy the condition N1n1 = N2n2.

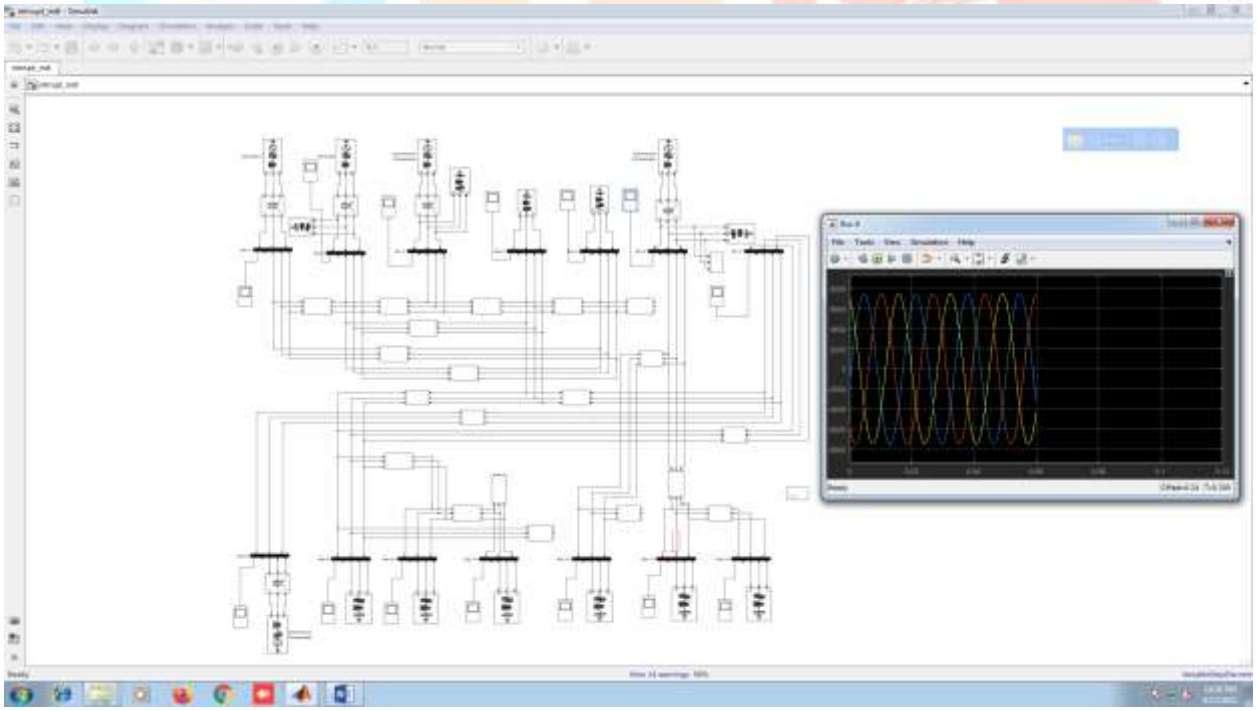


According to Fig. 2, under normal operation conditions, the CT secondary currents I1s and I2s are approximately equal. However, when an internal fault occur, this condition is no longer verified, and the difference between I1s and I2s becomes much large.

IV. RESULT

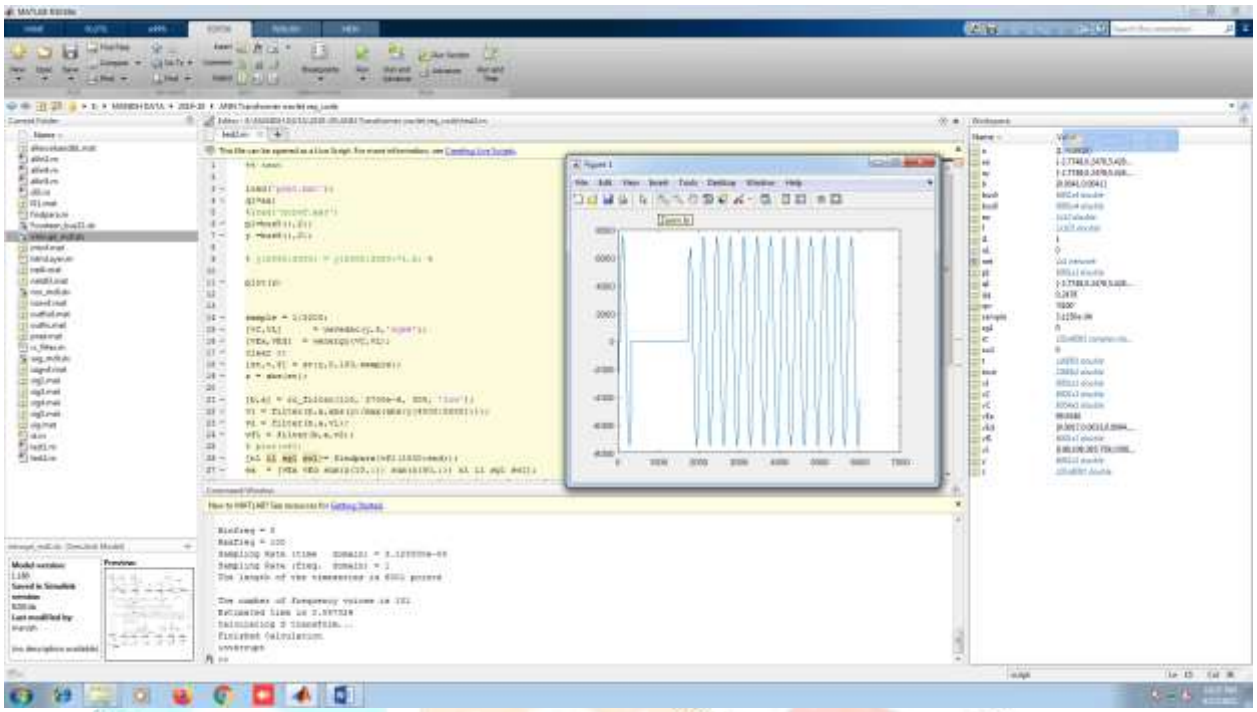
The algorithm uses wavelet based disturbance detector in order to detect any disturbance related to a power transformer, whereas a neural network based routine is used to classify the disturbance type (internal fault, external fault and transformer energization) appropriately, as well as to classify the internal faults. Several events were simulated, the motivation of this project was to design, simulate, and construct an IEEE 14 bus power system for future use in a lab setting to test, in real time, novel control techniques for various forms of generation and their impacts on the stability of the grid

Fourteen Bus bar System interrupt Fault

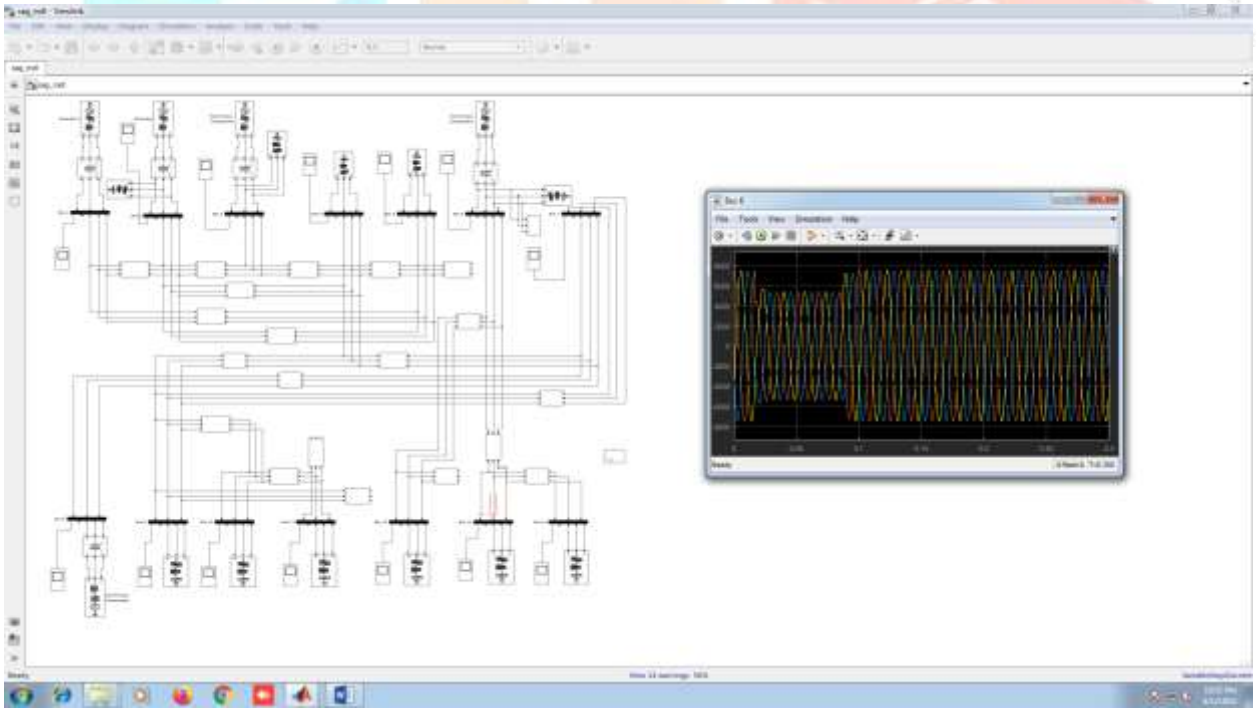


Classification Shows

Interruption

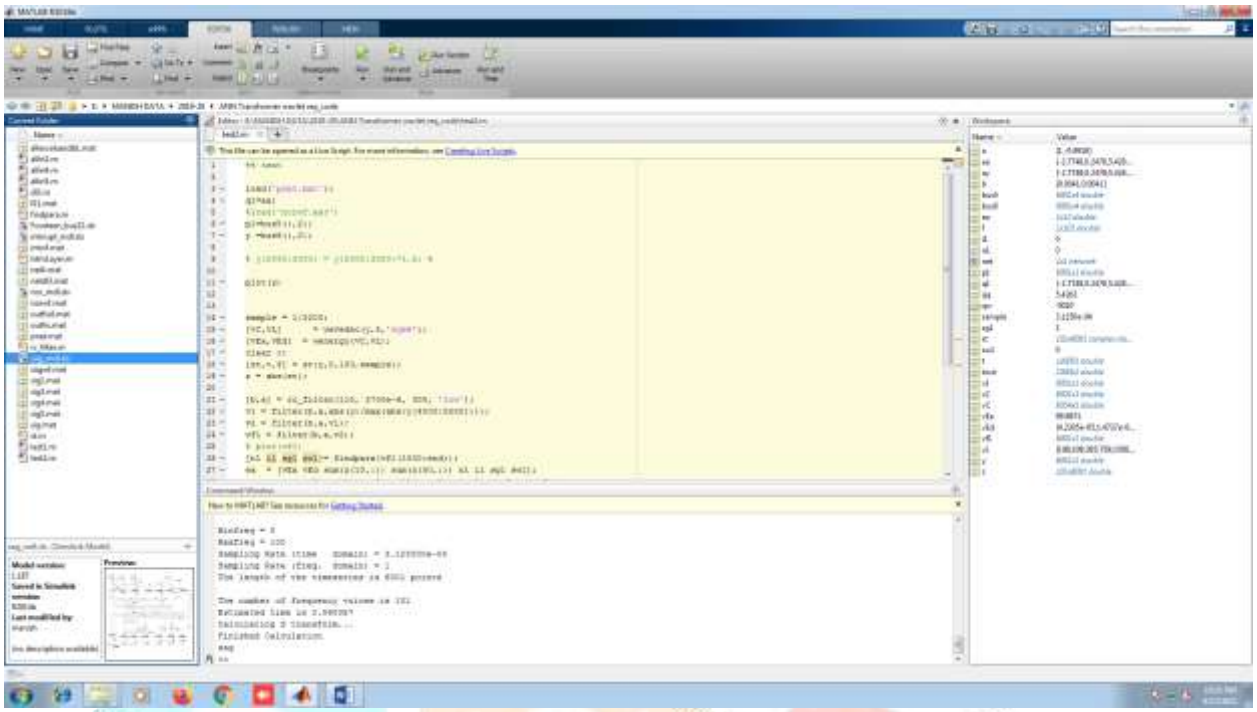


Fourteen Bus bar System SAG Fault



Classification Shows

SAG



CONCLUSION

A novel technique for distinguishing between inrush currents and short-circuit currents in transformer systems by combining wavelet transform and neural network technique. The ability of wavelets to decompose the signal into frequency bands in both time and frequency allows accurate fault detection. Since this method is used for discontinuity analysis of the signals, even if the fault occurs at the lowest time space with high impedance at the fault location, detail coefficients of the signal give us faulty condition.

The ANN correctly classifies the fault with advantages in accuracy and speed upon classical algorithms. A faster response is obtained since only a quarter of cycle from the occurrence of the fault is required. The performance shown demonstrates that the proposed technique gives a very high accuracy in classification of the transients (≈ 99%). The proposed technique can be used as an attractive and effective approach for alternative protection algorithm for large power transformers.

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