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"Analysis Of Fault Detection Using Artificial Neural Networks In HVDC Transmission Systems"

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Abstract: The increasing demand for reliable electrical energy necessitates fault-free operation of power systems. Power transformer protective relays play a crucial role in mitigating unwanted outages. This paper proposes the application of artificial neural networks (ANNs) for detecting and classifying faults in power transformers, leveraging their ability to mimic human knowledge and automate complex tasks. A comprehensive survey of soft computing approaches for transformer fault location is presented, highlighting the limitations of conventional techniques and the potential benefits of intelligent solutions

Index Terms **-**TransformerFaultLocation,ArtificialNeuralNetworks,Softcomputing,Artificial Intelligence, Gradient, KNN, Feature extraction and Accuracy

I. Introduction

The power system infrastructure requires robust protection against faults, anomalies, and undesirable conditions. To achieve this, protective relays and systems are employed. With the growing demand for reliable electrical energy in various sectors, power systems must operate with minimal faults. Power transformers, being critical and expensive components, necessitate advanced protection mechanisms. The primary goal is to reduce unwanted outages, which demands high-performance protective relays that operate with precision, speed, and dependability. This includes ensuring no false tripping and rapid fault detection and clearance.

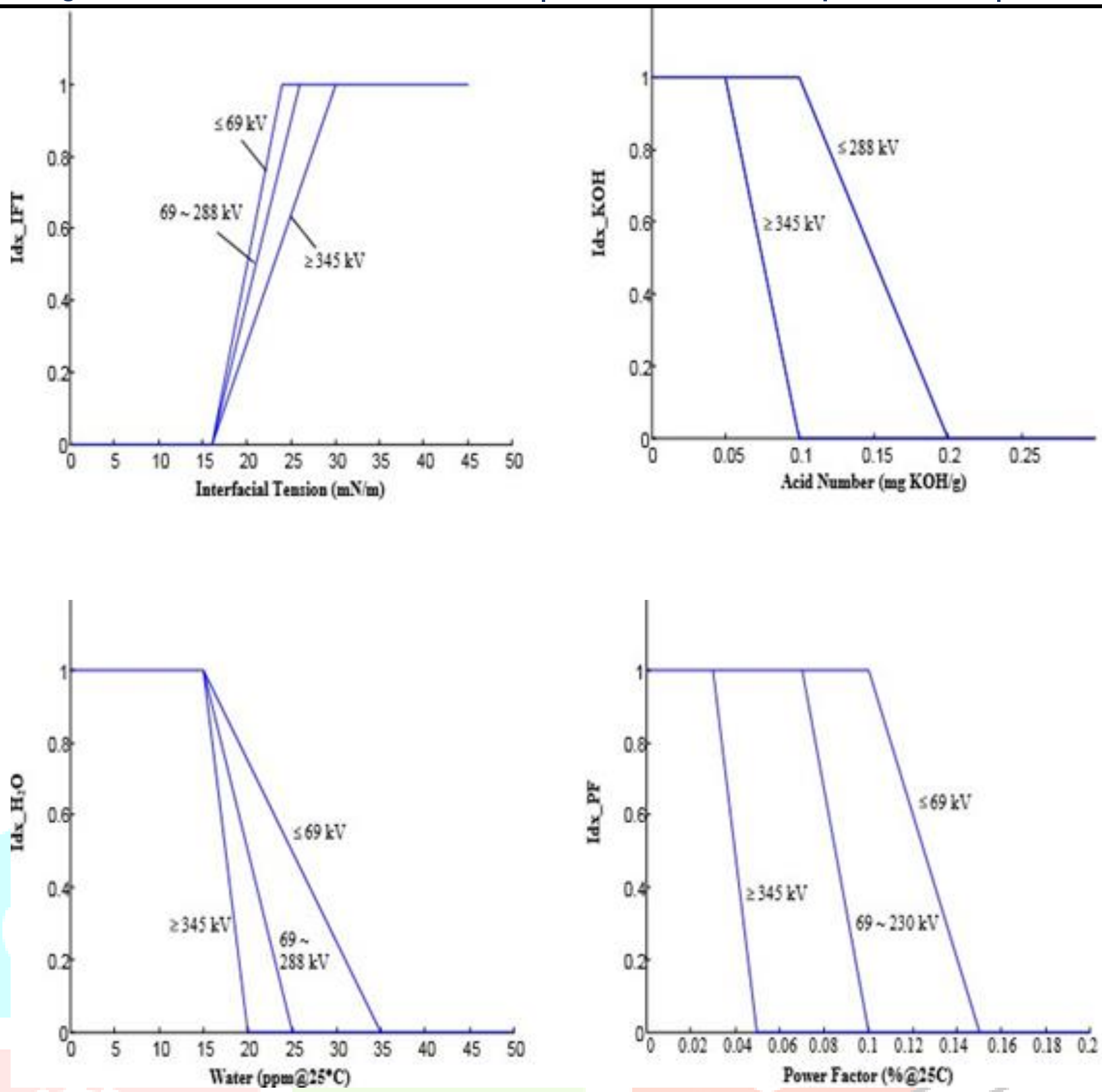

Fig.1.1TransformerOilConditionAssessmentIndices

The solubility of water in transformer oil increases with temperature. However, the formation of free water, which can significantly compromise the oil's dielectric strength, only occurs when the oil becomes saturated with water and the temperature drops. Thus, while high water content at elevated temperatures may be acceptable, it is crucial to ensure that the oil does not reach saturation. When measuring the power factor (PF) of transformer oil at temperatures other than 25°C, a correction factor must be applied due to the strong temperature dependence of PF.

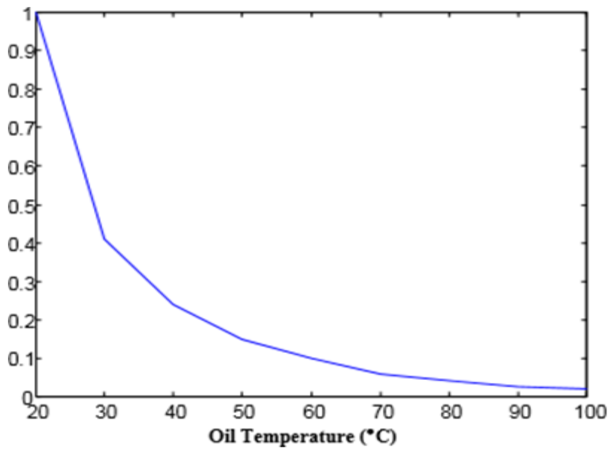

Fig.1.2TransformerOilPowerFactorCorrectionFactor

II. LITERATURESURVEY

The significant previous work in the domain has been summarized here with the salient features.Previous work in the domain helps in formulating the problem domain andrenders an idea into the basic mechanisms that have been already used for the purpose of transformer fault location. The different contemporarywork of authors has been cited here with their merits and approaches.

Jessika Fonseca discussed that 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 toolsbased on artificial intelligence and signal processing, such as themethods 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 [1].

Pretty discussed that the demand for a reliable supply of electrical energy for the need of modern world in each and every field has increased considerablyrequiring nearly a no-fault operation of power systems. The crucial objective is to mitigate the frequency and duration of unwanted outages related to power transformer puts a high pointed demand that includes the requirements of dependability associated with no false tripping, and operating speedwith short fault detection and clearing time. The second harmonic restrain principle is widely used in industrial application for many years, which uses discrete Fourier transform (DFT) often encounters some problems such as long restrain time and inability to discriminate internal fault from magnetizing inrush condition. Hence, artificial neural network (ANN), a powerful tool for artificial intelligence (AI), which has the ability to mimic and automate the knowledge, has been proposed for detection and classification of faults from normal and inrush condition **[2].**

III. *PROBLEMDOMAIN*

IntroductionofTransformerFaults

Transformer Fundamentals- A power transformer is a static device that transfers electrical energy between two circuits through electromagnetic induction, without a direct electrical connection. It maintains the same frequency while potentially altering the voltage level. The transformer's operation is based on Faraday's law of electromagnetic induction, which states that the induced electromotive force (EMF) in a conductor or coil is directly proportional to the rate of change of flux linkage over time. This fundamental principle enables the efficient transfer of power between circuits.

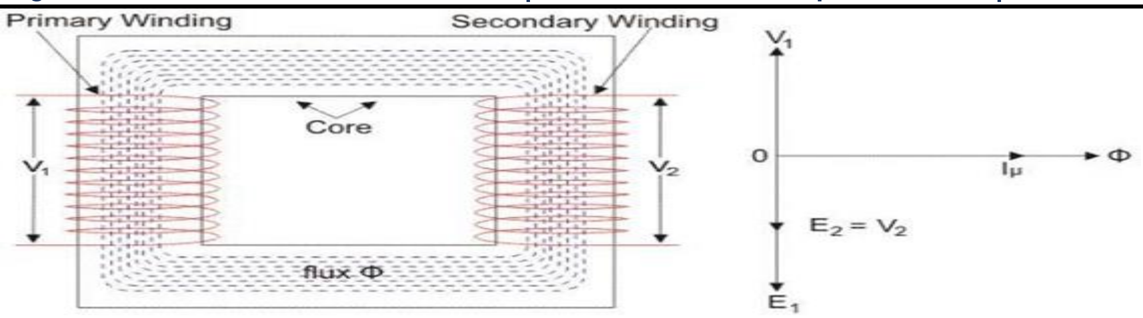

Fig. 1.3 Basic working of Transformer

Thethreemain parts of a transformer are,

1. PrimaryWindingofTransformer-whichproduces magneticfluxwhenitisconnectedto electrical source.
2. MagneticCoreofTransformer-themagneticflux producedbytheprimarywinding,that will pass through this low reluctance path linked with secondary winding and create a closed magnetic circuit.
3. Secondary Winding of Transformer- the flux, produced by primary winding, passes throughthecore,willlinkwiththesecondarywinding.Thiswindingalsowoundsonthe same core and gives the desired output of the transformer.

MagnetizingInrushCurrentinPowerTransformer

Inrush Current Phenomenon- Inrush current refers to the maximum instantaneous current drawn by an electrical device during startup or energization. When a power transformer is energized, a transient current surge, known as magnetic inrush, can occur, reaching up to 2-5 times the normal current for several cycles.

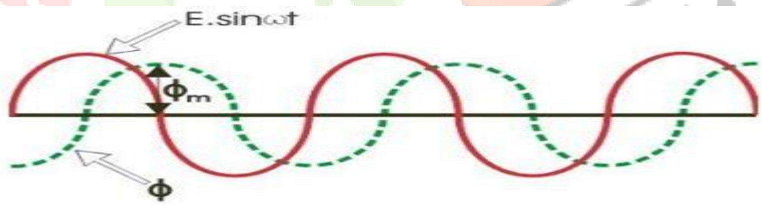

Fig. 1.4:Induced Voltage

IV. PROPOSEDMETHODOLOGY

ArtificialNeuralNetworks

Artificial neural networks (ANNs) offer a practical approach to implementing artificial intelligence, tackling complex problems that require substantial effort due to large data sizes and intricate relationships. ANNs are designed to mimic human thought processes, leveraging a structure that simulates the brain's neural connections to learn, reason, and make decisions.

- Processdataasaparallelstreamindependently
- Identifyingpatternsandcorrelatingthem.
- Evolvingandupdatingtheexperiences(calledweights)asperthechangesinthe data received. Neural networks work on training and testing mechanism.

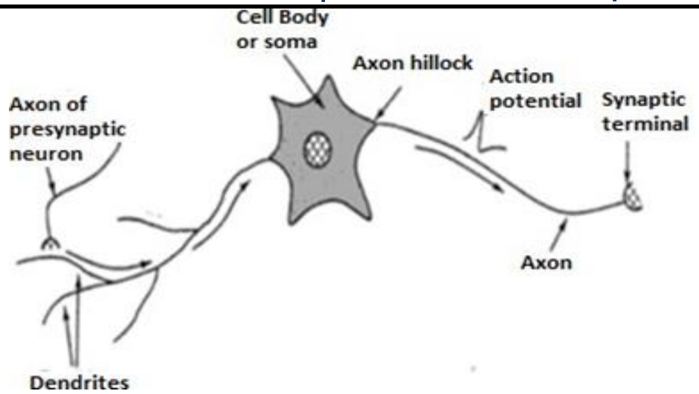

Fig. 1.5-Biological Model of Neuron

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IV. RESULTS AND DISCUSSION

Theresults havebeen presented in terms of the followingparameters for 2 different datasets

1) Theneuralnetworkdesignedhasbeendeliberatelykeptdevoidofmultiplehiddenlayers so as toreduce the space and time complexity of the system.

2) Theabove-mentioned point is particularlyuseful forrealtimecritical applications.

3) Theevaluationparametersare:

a) Classification accuracy

b) Confusionmatrix

c) Neuralnetwork trainingparameters

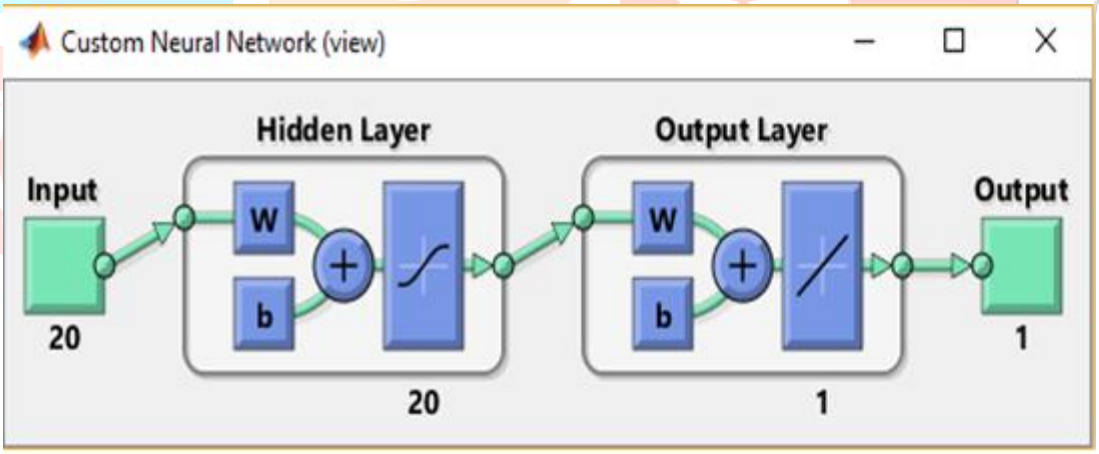

Fig. 1.6 –Neural Network For Classification

DataSet1.

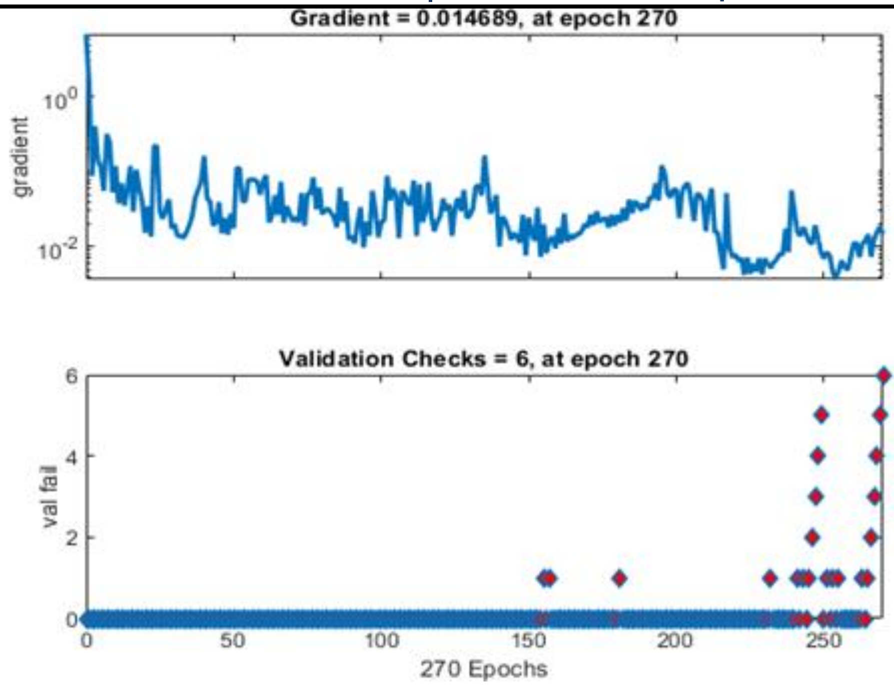

Fig. 1.7-Training States

V. CONCLUSION & FUTURE SCOPE

This study highlights the critical need for reliable power systems with minimal faults, particularly in power transformers. The primary objective is to ensure protective relays operate flawlessly, with high dependability, speed, and accuracy. Timely maintenance is essential but not sufficient for absolute reliability. Incipient faults can compromise insulation integrity, leading to catastrophic failures. Predicting fault probabilities heuristically is crucial. Wavelet transform and neural networks offer a promising solution. Wavelet transform extracts features from non-stationary signals, while neural networks classify and discriminate various conditions. The proposed system achieves a worst-case accuracy of 98%, surpassing conventional methods. This approach eliminates the need for expensive equipment and expert operators, making it a viable solution for power transformer protection.

Further improvement in existingsystems can be madeby:

1) Use of data pre-processing tools such as principal component analysis (PCA) which removes redundant training data and trains the neural networks more effectively.
2) Theclassificationoffaultscan alsobedone

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