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DETECTION OF FAULTS IN SYNCHRONOUS GENERATOR USING HYBRID ANN TECHNIQUE

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ABSTRACT

This paper introduces latest approach to the diagnosis of synchronous generator faults, which are very important to the quality of the power system. The method makes use of a hybrid artificial neural network (ANN) model, which combines conventional ANN techniques with advanced machine learning algorithms. Even with noisy data, this hybrid model can detect a variety of faults with accuracy. Enhanced fault diagnosis in synchronous generators could result in better maintenance and increased system reliability. Enhancing fault diagnosis in synchronous generators through hybrid ANN technique offers a favorable solution that will improve overall system reliability and maintenance. By combining Artificial Neural Networks (ANN) with the Ant Lion Optimizer (ALO) algorithm, this work provides an advanced approach for detecting problems in synchronous generators, which are essential parts of power systems.

Keywords: Synchronous Generator, Artificial Neural Network (ANN), Fault detection, Generator faults and diagnosis.

1. INTRODUCTION

The protection of synchronous generators with multiple parallel paths becomes more crucial as the electric power industry grows. Diagnostic and preventative measures are now the top priorities when it comes to synchronous generator reliability [1]-[2]. Permanent Magnet Synchronous Machines (PMSM) are being used more frequently, so it's critical to assess the machine's health status and, in the event of deterioration, identify the fault's nature and determine how serious it is. Different fault types in PMSMs can occur depending on the location of the machine and its operating environment. The generator's internal short circuit current could be many times higher than the terminal short circuit current [3]-[4]. The high current could cause significant heat generation and damage to mechanical parts. Therefore, a precise method for calculating the internal fault currents should be available for sufficient generator protection [5]-[7]. Internal faults pose a significant challenge for the protection of electrical machines, particularly ground faults in cases of high impedance grounding since differential relays, the most popular generator protection device, are unable to detect them. [8]- [10]. Consequently, a challenging issue in the field of fault diagnosis of electrical machines is the ability to reliably and accurately identify internal faults. The development of various protection techniques, including digital, artificial intelligence (AI), and other machine learning techniques, has been motivated by this fact over a long period of time[11]-[13].The synchronous generator has defects both internally and externally. On the other hand, external faults occur outside the generator and are brought on by overloading, unbalanced loading, and short circuits. Internal faults occur when there are phase-to-phase and phase-to-earth faults in the stator winding [14]-[15].For synchronous generator protection, electromechanical, solid state, and numerical relays used in differential protection are traditionally the most popular techniques. It is found that unless the fault develops and the current reaches operating value, traditional schemes such as differential protection schemes and stator earth fault detection schemes are slow to clear the faults. [16]- [18] Therefore, in order to extend the useful life and reliability of synchronous generators, it is crucial to conduct a careful analysis of internal faults [19]-[21]. Therefore, a difficult issue in the field of fault diagnosis of electrical machines is the reliable and accurate diagnosis of internal faults. Many techniques for the identification and diagnosis of malfunctions in dynamic systems that offer online electrical machine monitoring have been put forth in recent years. In the industry today, strong and operator-focused supervision concepts are in demand. [22]- [23] In general, the generator output waveforms provide crucial data for determining the charging system's state. An experienced technician can diagnose problems with generator parts like the voltage regulator, diodes, and stator coil using the output waveforms. In other words, the technician had discovered it was best to always check for minor issues before starting a major repair. However, many breakdowns are difficult to accurately classify using expertise in practical fault diagnosis among technicians [24]-[25].

2. HYBRID TECHNIQUES IN SYNCHRONOUS GENERATOR FAULTS ANALYSIS

Figure 1 shows the Block diagram of diagnosis of faults in synchronous generator using hybrid ANN technique. In order to improve accuracy and efficiency in synchronous generator fault analysis, hybrid techniques integrate modern technologies with conventional methods. A comprehensive evaluation of generator health is made possible by combining traditional fault detection techniques, like vibration analysis and thermal monitoring, with innovative instruments, like machine learning algorithms and digital signal processing. By reducing downtime and averting catastrophic failures, this synergistic approach helps in early fault detection. Hybrid approaches provide a more durable and dependable means of guaranteeing the stability and dependability of power generation systems by combining the advantages of both traditional and contemporary methodologies to optimize fault analysis in synchronous generators.

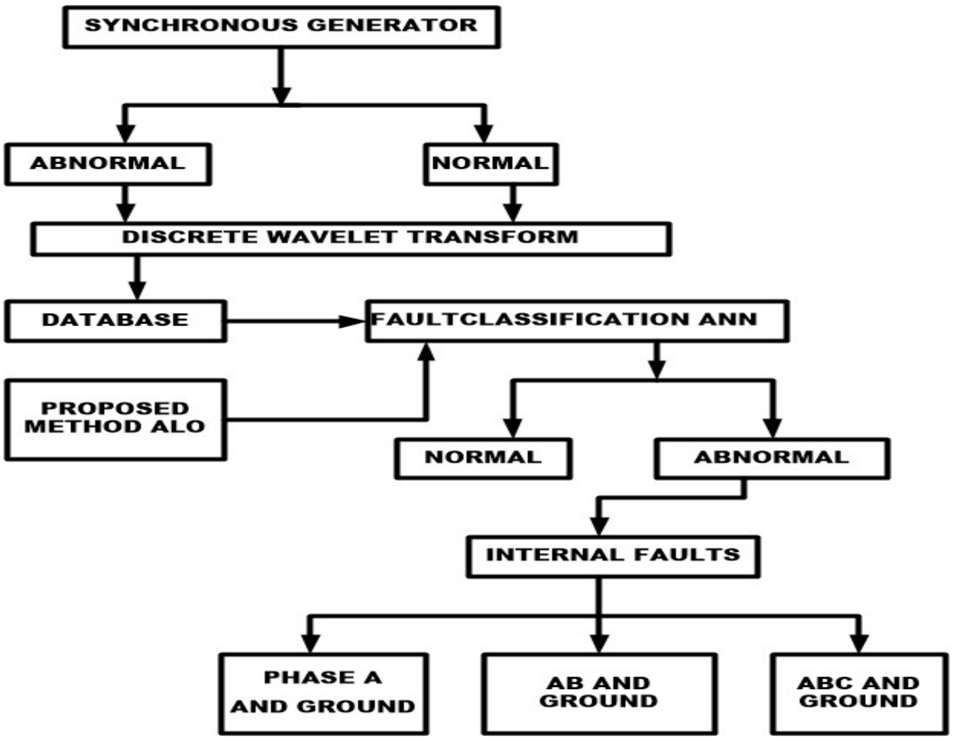

Figure.1 Block diagram of diagnosis of faults in synchronous generator using hybrid ANN technique

3. A COMPREHENSIVE INTRODUCTION TO ARTIFICIAL NEURAL NETWORK

Figure .2 shows the Pictorial representation of perceptron. Artificial Neural Networks (ANNs) are a key component of artificial intelligence because they resemble the composition and operations of the human brain. An ANN is a network of interconnected nodes or neurons that is skilled at tasks like pattern recognition, classification, and regression. ANNs learn from patterns in data. The architecture of the network consists of input, hidden, and output layers, and weights are adjusted during training to maximize efficiency. Because of adaptive learning, artificial neural networks (ANNs) can accurately predict new, unseen data and generalize from training data. As ANNs continue to develop and are widely used in a variety of fields, including forecasting, natural language processing, and image recognition, machine learning and artificial intelligence applications will continue to be innovative.

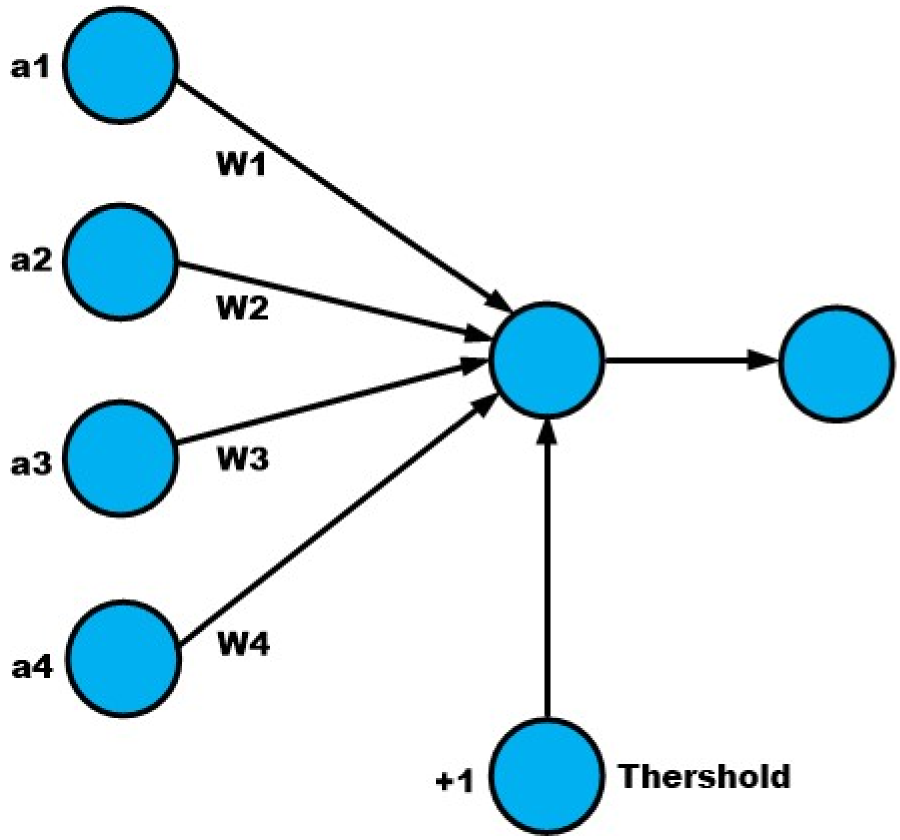

Figure.2 Pictorial representation of perceptron

A "perceptron" is used as the basic unit instead of a neuron when writing an artificial neural network (ANN). Several weighted inputs can be summarized by the perceptron, which will activate and send an output if the total input exceeds a threshold. Typically, the activation function selects an output between 0 and 1 or −1 and 1, depending on the situation. Given that the activation function derivative is frequently utilized in network training, it is advantageous if the derivative can be expressed in terms of the original function value because doing so requires fewer extra computations.

4. ALO ALGORITHUM

ALO is an innovative form of meta-heuristic that resembles how ants and antlions interact in the real world through mathematical simulations. To address optimization issues resulting from the use of ant random walks, trap construction and entrapment, prey capture, and trap re-building, an algorithm for optimization has been created. The five fundamental steps of a hunt in larvae are replicated by the ALO algorithm, as was previously established: ant random movement, trap construction and entrapment, prey capture, and trap reconstruction.

A. Random Walks of Ants

Irregular walks are altogether founded on condition beneath:

$$X(t)=\begin{bmatrix} 0, cumsum\left(2r\left(t_1\right)-1\right), \\ cumsum\left(2r\left(t_2\right)-1\right),..., \\ cumsum\left(2r\left(t_n\right)-1\right), \end{bmatrix} \quad (1)$$

Where cumsum processes the total entirety, n is the most outrageous number of cycle, t exhibits the movement of the self -assertive walk and r(t) is a stochastic limit described as seeks after

$$r(t)=\begin{matrix} 1 & rand > 0.5 \\ 0 & rand \leq 0.5 \end{matrix} \quad (2)$$

B. Random walks of ants: The following equation updates the ant's position using the random walk explained above:

$$X_i^t=\frac{\left(X_i^t-a_i\right)\left(d_i-C_i^j\right)}{\left(d_i^t-a_i\right)}+C_i \quad (3)$$

C. Trapping in Antlion's pits: The following model describes how antlions affect ant movement:

$$C_i^t=Antlion_j^t+C^t \; \& \; d_i^j=Antlion_j^t+d^t \quad (4)$$

D. Building trap: The construction of traps is done with a roulette wheel. The roulette wheel operator selects the lions during optimization by considering their level of fitness. This method also increases the fitter antlions' chances of catching ants.

E. Sliding ants towards antlion

The step of the hut's mathematical representation is shown below. Equation shows that the radius of the hyper-sphere created by the random travels of ants is adaptively reduced.

$$c^t=\frac{c^t}{I} \; \& \; d^t=\frac{d^t}{I} \quad (5)$$

F. Rebuilding the pit and capturing prey

When ants become physically fitter (dives deeper into the sand than their linked antlion), they can catch prey in ALO. Then, to increase its chances of snagging fresh prey, an antlion must move to align with the chased ant's most recent location. This behaviour can be simulated using the following equation.

$$Antlion_j^i=Ant_i^t \text{(11)If } f\left(Ant_i^t\right)>f\left(Antlin_i^t\right) \quad (6)$$

G. The Elite

The ability of evolutionary algorithms to hold on to the best solution or solutions found at any given stage of the optimization process is known as elitism. The best antlions from each iteration are retained and treated as an elite group in this study.

$$Ant_i^t=\frac{R_A^t+R_E^t}{2} \quad (7)$$

H. Binary ALO

A threshold function is used by BALO, the binary equivalent of ALO, to resolve discrete optimization issues.

I. Multi-objective of ALO

Multi-objective issues have been proposed to be solved using MOLAO [3], a multi-objective variation of ALO. Pareto optimum fronts are saved and improved by MOALO using an archive.

J. Discrete Wavelet Transform (DWT) Configurations

A technique for processing signals that separates signals into discrete frequency components and produces a time-frequency representation is called the Discrete Wavelet Transform (DWT). DWT extracts information at both high and low frequencies by using high-pass and low-pass filters. Different configurations meet different requirements; for example, the Single-Level DWT uses only one decomposition level, while the Multi-Level DWT offers a detailed frequency analysis with multiple levels. Furthermore, DWT uses various wavelet functions, such as Hear and Daubechies, to improve its flexibility. Due to its adaptability, DWT performs exceptionally well in a variety of applications, including image processing and audio analysis, when it comes to tasks like demising, compression, and feature extraction...

5. SIMULATION RESULTS

Figure .3 shows the simulation of Diagnosis of faults in Synchronous Generator using Hybrid ANN technique. The synchronous generator's classification of work faults is examined in this chapter using the ANN and ALO algorithms. For a variety of reasons, the synchronous generator developed an internal fault.

DWT algorithms are used to extract the data for the fault signals. The data are used to identify the specific synchronous generator fault. High efficiency is attained in the classification of synchronous generator faults. The information required to locate the synchronous generator's faults during a fault is stored in the artificial neural network (ANN). The ANN can be trained by applying the ALO algorithm. This algorithm offers an extremely effective and transparent internal fault diagnosis. The model, plan, and execution against internal fault issues of the suggested hybrid technique-based synchronous generator are all made very clear. Figure .4 shows that the fault is created between the phase A and ground and the waveform shows the abnormal condition. Figure.5 shows that the fault is created between the phase AB and ground and the waveform shows the abnormal condition. Figure.6 shows that the fault is created between the phase ABC and ground and the waveform shows the abnormal condition.

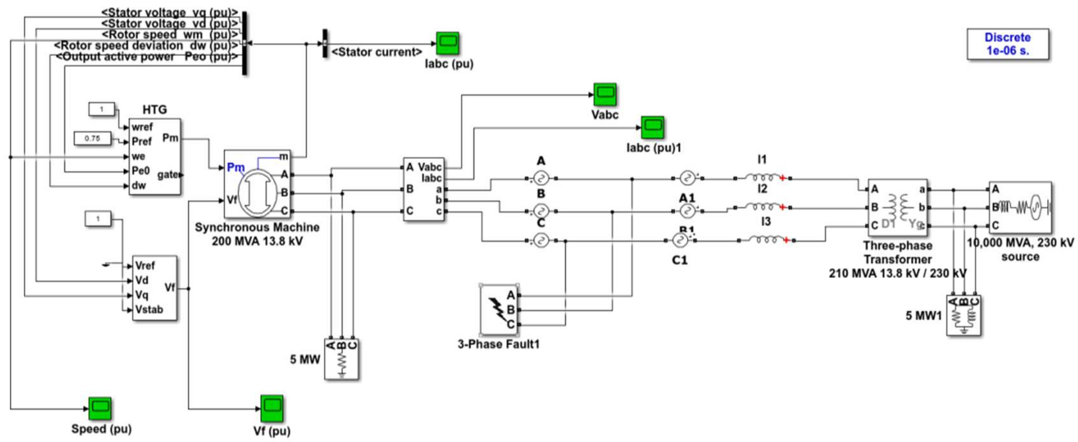

Figure.3 Simulation of Diagnosis of faults in Synchronous Generator using Hybrid ANN technique

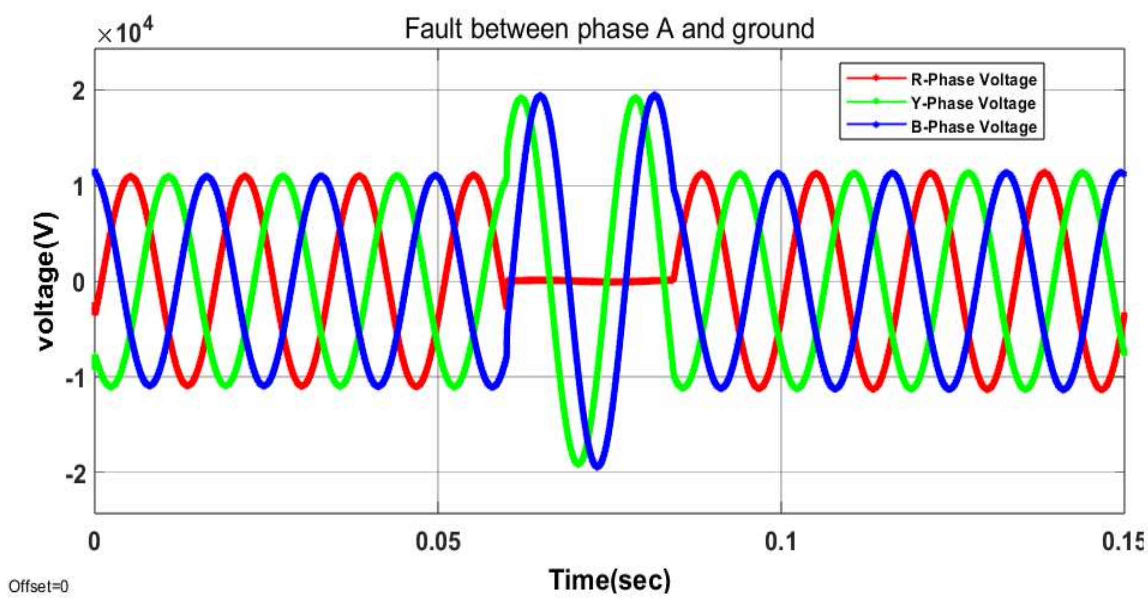

Figure.4 shows that the fault is created between the phase A and ground and the waveform shows the abnormal condition.

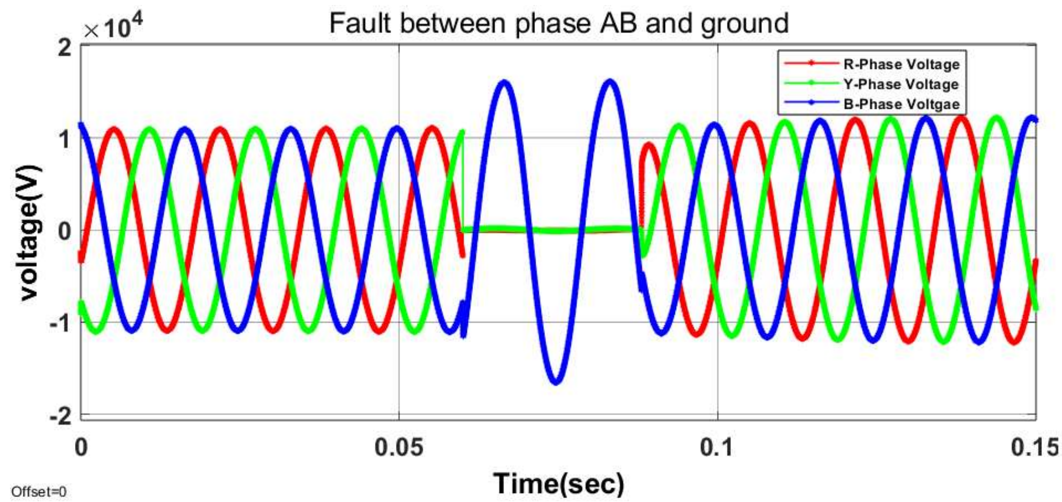

Figure.5 shows that the fault is created between the phase AB and ground and the waveform shows the abnormal condition.

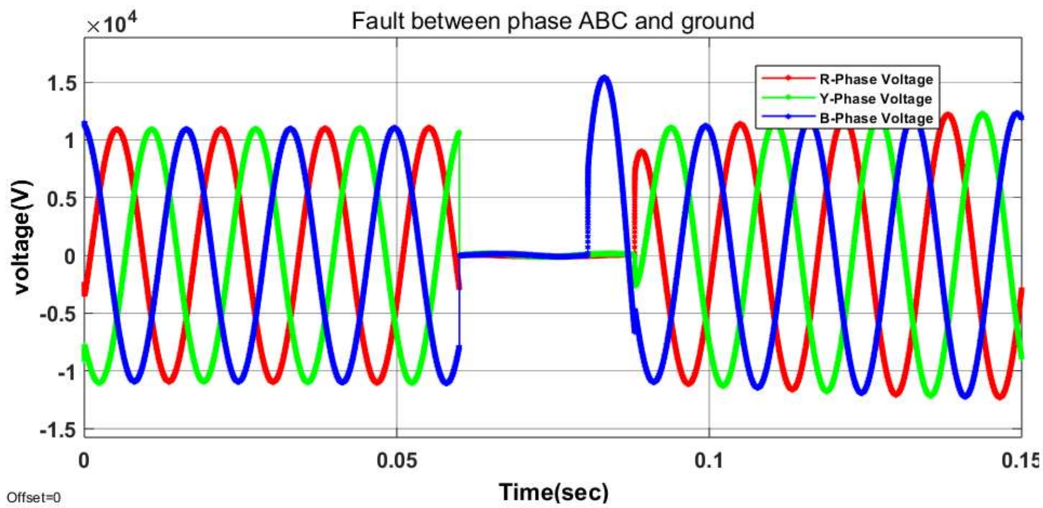

Figure.6 shows that the fault is created between the phase ABC and ground and the waveform shows the abnormal condition.

6. CONCLUSION

The utilization of Anti lion optimizer (ALO) and Enhanced Artificial Neural Networks (ANN) for fault classification in synchronous generators is a noteworthy development in fault diagnosis methods. This study has shown that these algorithms are capable of reliably and successfully identifying a wide range of synchronous generator faults. The overall effectiveness and dependability of fault detection systems are improved by the combination of ANN's learning capabilities and ALO's optimization strategies.This creative solution reduces maintenance expenses and downtime while also enhancing the generator's operational safety. The efficacy of this methodology highlights its potential for immediate implementation in power systems, guaranteeing a consistent and steady flow of electricity. The ongoing improvement of fault diagnosis methodologies and power system reliability depends on more study and application of these approaches.

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