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Predictive Neural Network Approach for High Impedance Fault Detection and Isolation in Power Systems

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ABSTRACT

This paper proposes an accurate High Impedance Fault (HIF) detection and isolation scheme in a power distribution network using neural network .High impedance faults (HIFs) pose significant challenges in modern power distribution systems due to their intermittent nature and low fault currents. Traditional protection schemes often struggle to detect these faults accurately, leading to potential safety hazards and power system instability. In this research, we propose a novel approach utilizing neural networks for the detection of high impedance faults. By leveraging the capabilities of neural networks in pattern recognition and classification, we aim to enhance the reliability and accuracy of HIF detection. This paper presents the methodology, experimental setup, and results of our investigation into the application of neural networks for HIF detection.

Keywords – HIF, MATLAB, Neural Network, Power System, Transmission Line Faults.

1.INTRODUCTION

When an overhead power line undergoes physical rupture and descends to the ground or establishes connection with the ground via any intermediary object, it triggers a well-established phenomenon termed high impedance faults (HIFs).These events often coincide with the occurrence of an electric arc, posing potential fire hazards, inflicting damage on electrical infrastructure, and jeopardizing human safety. High impedance fault (HIFs) are commonly encountered fault in power distribution system characterized by their low fault currents and intermittent nature. These faults often go undetected or misclassified by traditional protection schemes, posing serious safety risks and reliability issues.

As Defined by the Power System Relaying and Control Committee of the Institute of Electrical and Electronics Engineers (IEEE PSRC), a HIF arises when an energized conductor inadvertently connects with a non-conductive surface (such as soil, vegetation, tree branches, asphalt, or concrete), resulting in a restriction of fault current to a lower magnitude. Consequently, these faults elude detection by conventional overcurrent protection mechanisms [1]. Therefore, the detection and pinpointing of HIFs remain pressing challenges for protection engineering, constituting an ongoing, unresolved issue.

2. LITERATURE REVIEW

Past studies related to HIF detection have delved into a range of methodologies, encompassing impedance-based techniques, wavelet transforms, and artificial intelligence (AI) algorithms. Although impedance-based methods have demonstrated potential, they frequently exhibit sensitivity to system parameters and possess constrained fault detection capabilities. Conversely, wavelet transform-centric approaches boast enhanced fault detection efficacy but necessitate substantial signal processing and feature extraction efforts. Notably, in recent times, AI methodologies, with a particular focus on neural networks, have garnered attention owing to their adeptness in assimilating intricate patterns and proficiently categorizing data.

For example, the initial model proposed utilized measurements focusing on a low-frequency spectrum [2]. This model incorporated two diodes and two three phase sources (D.C.) voltage sources to characterize the behavior of HIFs. Subsequent research efforts have aimed to refine this model by incorporating additional elements such as linear resistances and inductances [3]. However, more sophisticated models have sought to provide a more comprehensive understanding of the physical conditions during HIF occurrences by including non-linear resistances within the diode-based framework [4]. Some of these models have incorporated time-varying non-linear resistances to capture the non-linearity and asymmetry of voltage-current characteristics. They consider one cycle of steady-state during the fault period and also account for the build-up and shoulder characteristics of the current waveform derived from the transient state [5]. Additionally, models grounded in thermal equations of the arc, supported by the Mayr and Cassie equations; determine arc model parameters and high resistance values through experimental measurements [6].

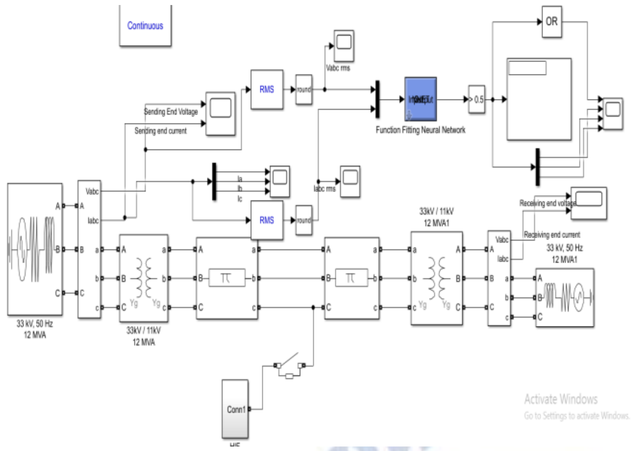
Moreover, researchers have explored various techniques for HIF detection, including a Kalman filter-based approach to identify variations in the fundamental frequency of the fault current and its harmonics [7]. Time-frequency analysis methods, such as the discrete wavelet transform (DWT), have been proposed for HIF detection due to their ability to provide qualitative and quantitative multiresolution analysis, facilitating HIF identification [8], [9]. Additionally, a method integrating the Gabor transform (GT) and Wigner distribution (WD) has been introduced for HIF detection [10]. Furthermore, a mathematical approach based on orthogonal component decomposition has been utilized for HIF detection [11]. Another study introduced an algorithm based on evidential reasoning to differentiate and classify switching events from HIFs [12]. Decision trees (DT) and extended Kalman filter (EKF) techniques have also been employed to estimate the harmonic content of the fault current, serving the purpose of HIF detection [13].

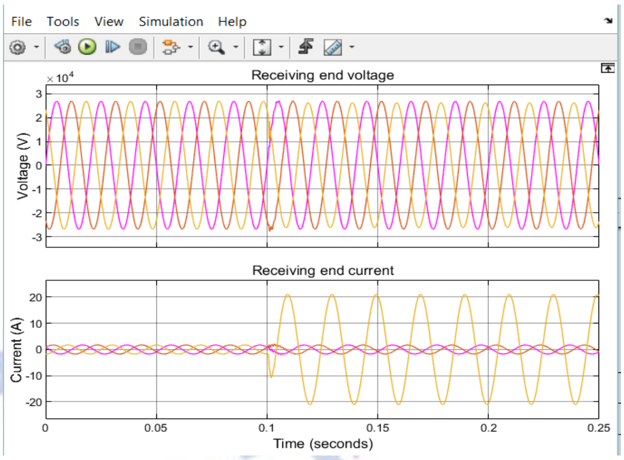
3.METHODOLOGY

In this study, we propose a neural network-based approach for the detection of high impedance faults in power distribution systems. The methodology involves the following steps:

1. Data Collection: Real-world data containing both normal operating conditions and simulated HIF scenarios are collected from power distribution networks.
2. Data Preprocessing: The collected data is preprocessed to remove noise, normalize features, and prepare it for training.
3. Neural Network Design: A neural network architecture suitable for fault detection is designed, taking into account the complexity of HIF patterns and the characteristics of the input data.
4. Training: The neural network is trained using the preprocessed data, employing techniques such as backpropagation and gradient descent to optimize its parameters.

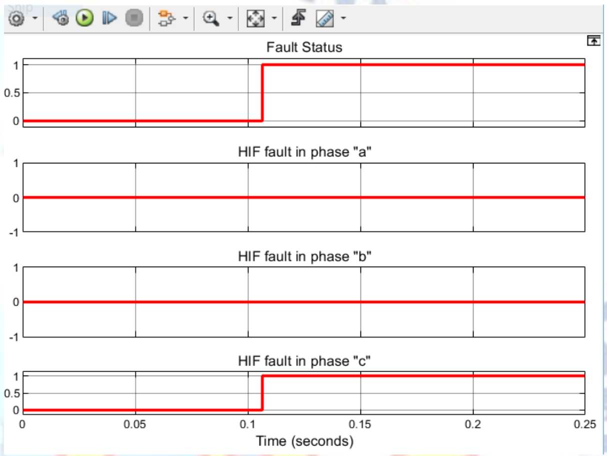
Testing and Evaluation: The trained neural network is tested on unseen data to evaluate its performance in detecting HIFs. Metrics such as accuracy, precision, and recall are used to assess the effectiveness of the proposed approach

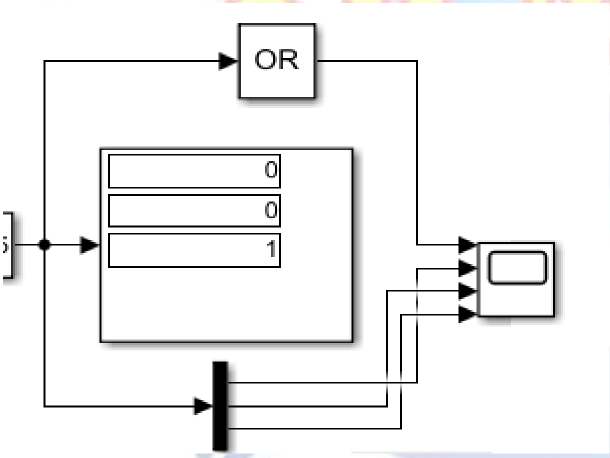


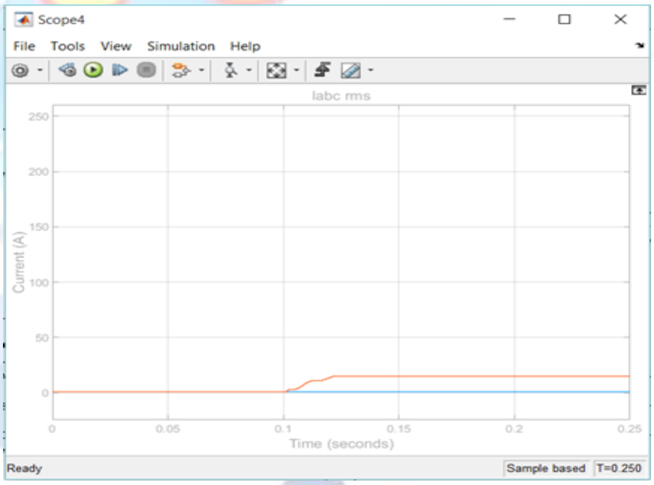


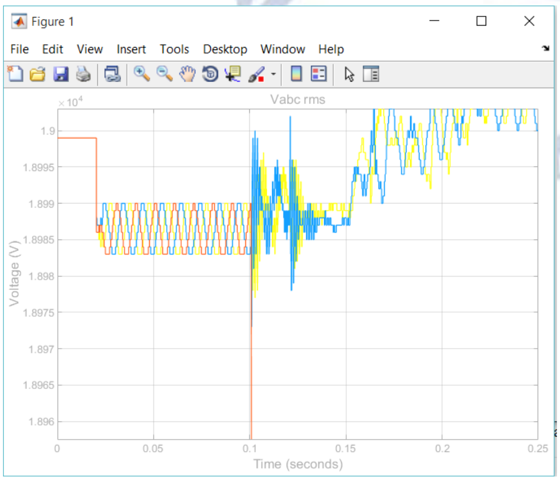
5. RESULTS AND DISCUSSION

The results of the experiments demonstrate the effectiveness of the proposed neural network-based approach in detecting high impedance faults. Compared to traditional protection schemes, the neural network exhibits higher accuracy and reliability in identifying HIFs, even under challenging conditions such as varying fault impedance and noise levels. Furthermore, the neural network demonstrates robustness against false alarms and adapts well to changes in system parameters.









6. CONCLUSION

In conclusion, this research presents a novel approach for the detection of high impedance faults using neural networks. By leveraging the capabilities of artificial intelligence, specifically neural networks, we have achieved improved fault detection performance compared to traditional methods. The proposed approach offers a promising solution to the challenges posed by HIFs in power distribution systems, contributing to enhanced safety, reliability, and stability.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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