UNIVERSITI TEKNOLOGI MARA

IDENTIFICATION OF EXCESSIVE NEUTRAL-TO-GROUND VOLTAGE IN SECONDARY DISTRIBUTION SYSTEM USING DEEP LEARNING METHOD

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ABSTRACT

Excessive neutral-to-ground voltage (ENTGV) in power distribution systems poses a critical challenge to the integrity and reliability of electrical networks. This thesis undertakes a comprehensive exploration to address this issue by focusing on model development, factor classification, and localization techniques. A detailed electrical circuit model is developed to characterize a normal neutral-to-ground voltage (NTGV) profile within a secondary distribution system (SDS), taking into account load conditions, grounding components, and the incorporation of ground return current. The model serves as a benchmark for understanding baseline NTGV behaviour and is intended for validation using future real-world data. Its performance is rigorously evaluated against existing models by using empirical measurement data, demonstrating improved alignment with observed system behaviour. To classify the contributing factors of ENTGV, a deep learning (DL) approach is proposed, leveraging raw waveform inputs without the need for manual feature extraction. This approach allows for more flexible and automated learning, capturing complex patterns in the data. The model's robustness is validated through a 5-fold cross-validation process, ensuring reliable and unbiased performance evaluation. A comparative analysis of key metrics, including accuracy, F1-score, and computational efficiency, highlights the proposed model's superiority over baseline DL model and conventional machine learning approaches. While a 100% accuracy was observed in the test set, this result is contextualized within the scope of available data and the specific ENTGV scenarios evaluated. Furthermore, this research introduces a novel localization technique to identify the source of ENTGV, determining whether it originates upstream or downstream of the measurement point within the SDS. By employing a hybrid DL model, the method effectively captures the intricate temporal and spatial characteristics of ENTGV, enabling accurate and efficient localization with an accuracy of 98.28%. This capability is essential for implementing timely corrective actions, ultimately improving the stability and safety of the network. The practical implementation of the proposed framework within the SDS facilitates the identification of ENTGV issues nearer to the end user, enabling more responsive maintenance and reducing disruptions at the consumer level. Overall, the findings of this study provide valuable insights into the factors contributing to ENTGV, supporting the optimization of power distribution system design, operation, and maintenance.

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CHAPTER 1
INTRODUCTION

1.1 Research Background

Neutral-to-Ground Voltage (NTGV) presents challenges in electrical systems, arising from factors like faults, imbalances, harmonics, grounding issues, and others. These factors induce voltage differences between the neutral conductor and the ground in systems with grounded neutrals, where theoretically, the voltage should be zero [1]. This voltage variation can lead to safety hazards and equipment damage, including electrical shocks that may harm personnel and disrupt sensitive electronic equipment. In the context of power quality (PQ), NTGV is a parameter that is closely monitored to assess the health and stability of an electrical system. Thus, excessive NTGV (ENTGV) can be an indicator of potential PQ issues that pose a significant challenge in the electrical system [2].

In some countries, ENTGV is also known as stray voltage (SV), neutral to earth voltage (NEV), and tingling voltage (TV) [3]. Regardless of the terminology used, ENTGV negatively impacts equipment, animals, and humans within the electrical system. This unwanted voltage results in nuisance tripping of the residual current device (RCD) and damages electronic equipment, causing substantial resource losses [4]. The consequences of ENTGV also extend to sensitive equipment like electronic appliances, communication systems, and computers, where it can potentially cause damage [5][6][7]. Further scenarios demonstrate that the industry's production, both in quality and quantity, tends to decline when a significant number of machines encounter ENTGV [8]. This issue arises when machinery becomes intensified and starts malfunctioning. Additionally, the reports which publish by Liu et al. [9], indicate that ENTGV contributes to an increase in the error rate during data transmission. This issue may occur when the electromagnetic noise generated by ENTGV disrupts the functioning of the output and input pins of machine components. Therefore, the programmable machine exposes to execute incorrect instructions.

The ENTGV not only harms electrical appliances but also poses life-threatening risks. Its potential consequences extend beyond agricultural operations, impacting livestock, especially dairy cattle. When electronic devices producing harmonics, such