Fault detection in DC microgrids based on machine learning

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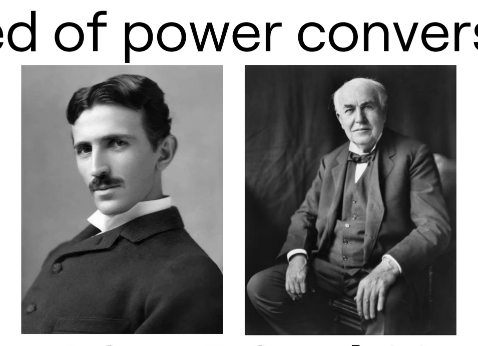
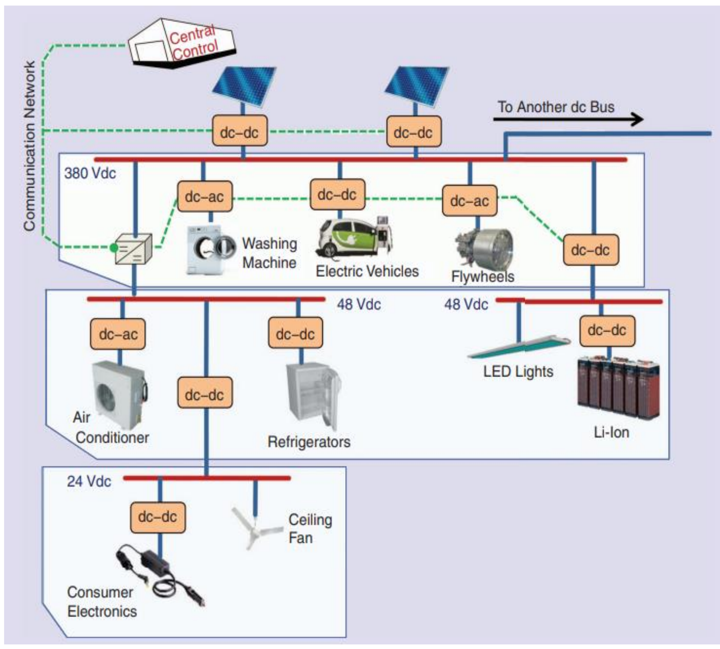
1. Introduction

The concept of microgrids was introduced in response to an increasing integration of distributed energy resources (DERs) into the power system. Although microgrids can be quite diverse, they generally contain DERs, energy storage and controllable or noncontrollable loads.

Advancements in power electronics enabled creation of DC microgrids which combine DC loads and power sources together, eliminating the need of power conversion.



AC vs DC vol.2?



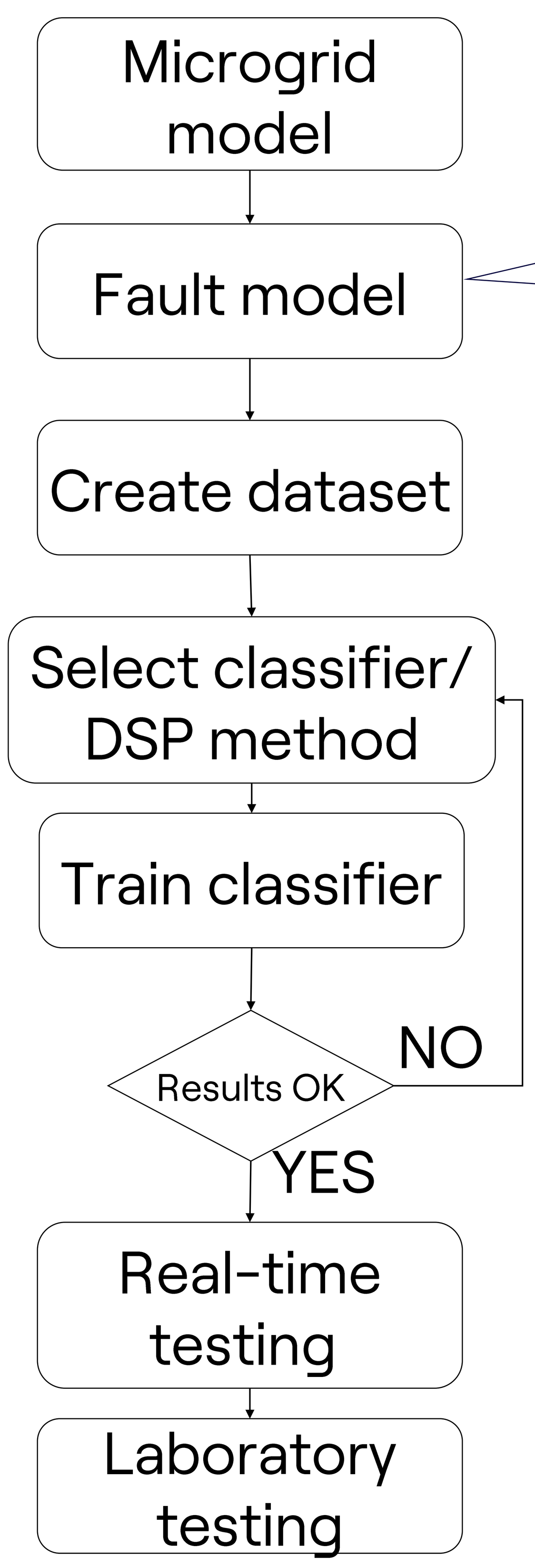
DC Microgrid

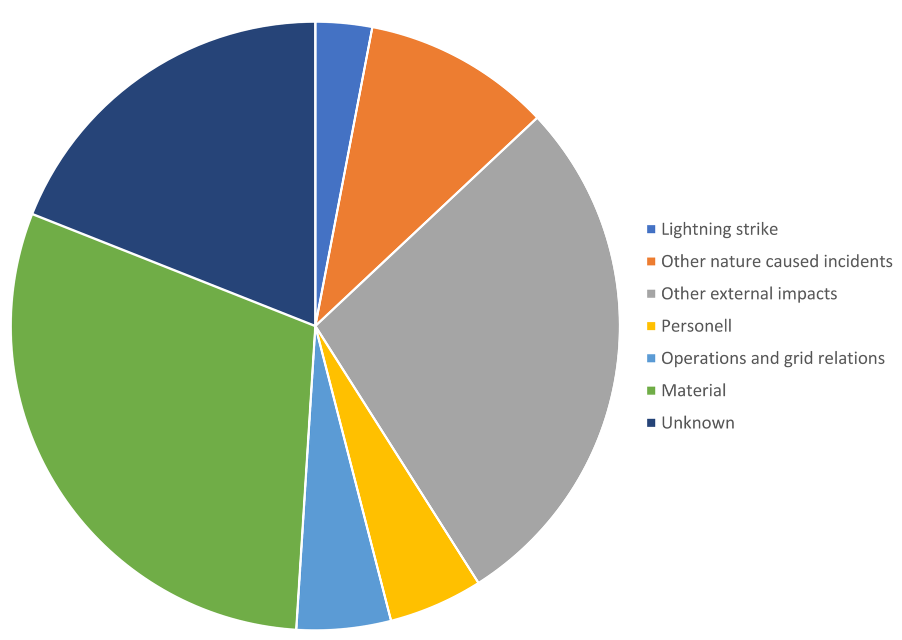
2. Problem Description

Although there are many benefits, the safety of DC microgrids remains an open problem. The reason for this is related to the characteristics of DC fault currents, which is different from that of the conventional AC systems.

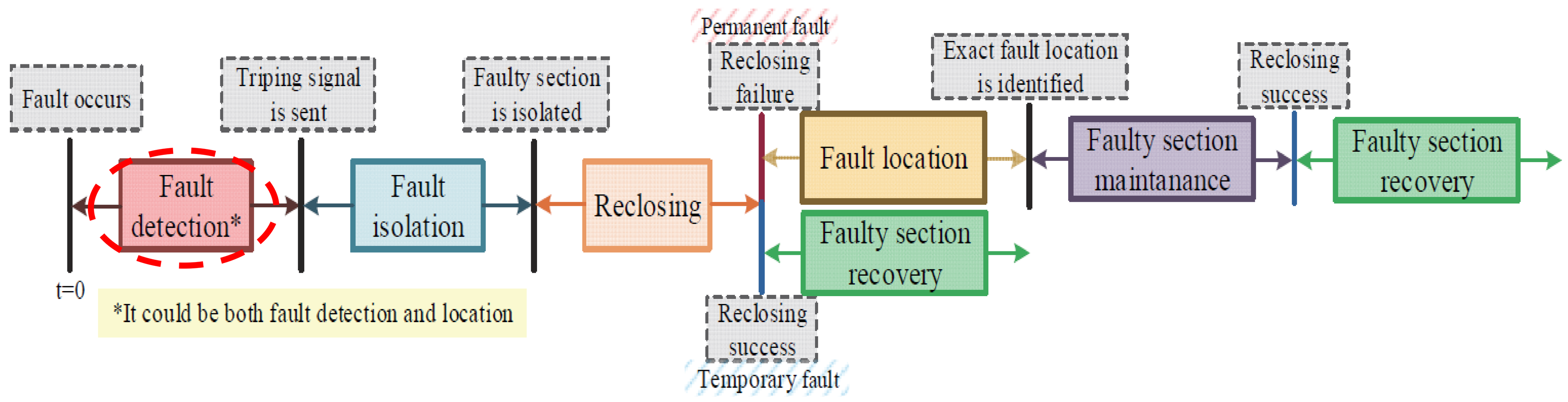
3. Methodology

Advanced fault detection methods have been developed to improve the safety of DC microgrids by enhancing the performance of the microgrid's protection system. These methods aim to enable the fast detection of high-current short-circuit faults and low-current faults that conventional methods have difficulty detecting. Machine learning models are combined with digital signal processing (DSP) methods to identify harmful patterns in voltage and current signals.





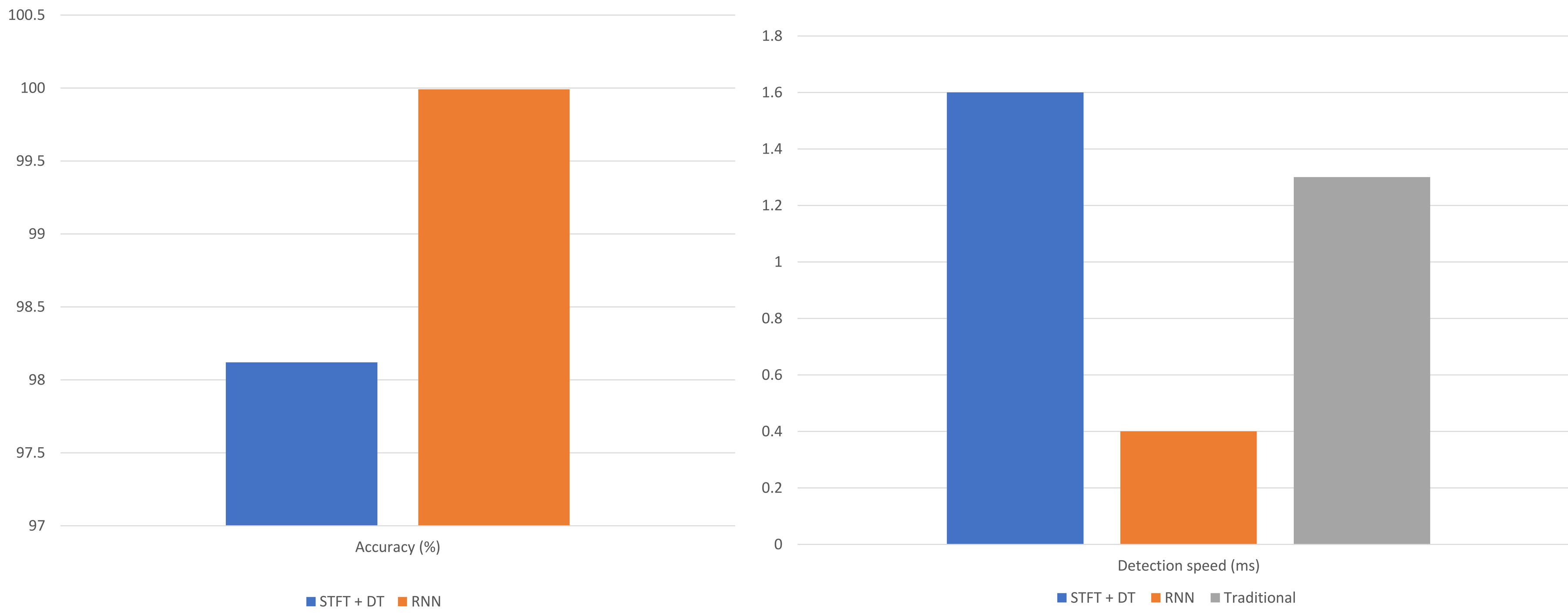
Fault causes



Protection process

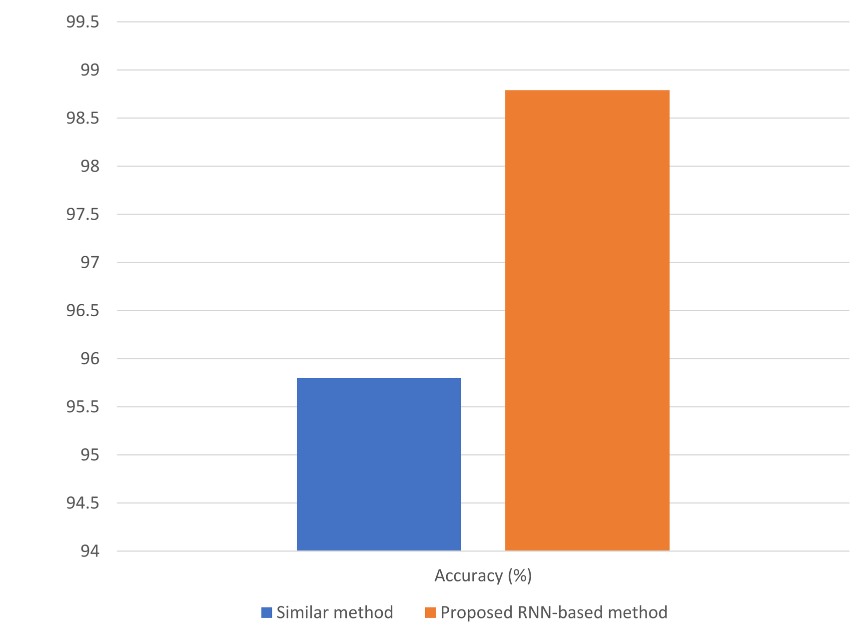
4. Results

Classical machine learning models, such as Decision trees (DT) and Support vector machines (SVM), are combined with digital signal processing methods, such as Short-time Fourier transform (STFT), to accurately detect short-circuit faults, also known as low-impedance faults (LIFs). To further improve detection speed, Recurrent Neural Networks (RNNs) have been explored for the same problem. RNNs have also been applied to detect high-impedance faults (HIFs), which most conventional methods are unable to detect.



Accuracy and speed comparison - LIF detection

While low-impedance faults are relatively easy to detect, improvements in their detection speed are desirable, and the proposed RNN-based method achieves this goal. The high-impedance fault detection method also achieves a high accuracy score, but its effectiveness is dependent on the specific fault model used.



Accuracy of HIF detection

5. Conclusion

The safety of DC microgrids continues to be a significant challenge that hinders their implementation, despite the numerous benefits they offer over their AC counterparts. Fast transients require a rapid fault detection method, and the objective of this research is to introduce advanced methods that enhance the protection process by reducing the fault detection time. Another goal is to implement these advanced methods to detect faults that conventional protection methods cannot identify. The proposed methods, which have demonstrated high accuracy and speed, will be tested in real-time and further developed.

Acknowledgments

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