Fuzzy Diagnosis of Faults for DFIG used in a Wind Energy Conversion System

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ABSTRACT

Currently, the diagnosis of possible faults in the wind power chain is a major priority for industrialists in particular and scientists in general. In addition to that, wind systems must be able to provide consistent service for a considerable amount of time, even if there is an electrical failure in the grid or any part of the conversion system. This paper is focused on introducing a diagnostic approach based on fuzzy logic. Its core purpose is to enable the continuous monitoring and timely detection of inter-turn short circuits and open-phase circuits occurring within the stator windings of wind turbines that employ double-fed induction generators (DFIG). The proposed approach relies exclusively on phase currents for real-time fault detection and localization in machines that incorporate double-fed induction generators (DFIGs) in wind turbines. This dependency is established through the acquisition of stator currents and the subsequent calculation of their average absolute values. To bring this innovative approach to life, the study leverages the powerful modeling capabilities of MATLAB/SIMULINK, Furthermore, the research presents simulation results to effectively demonstrate how the monitoring approach performs under distinct operating conditions.

Keywords: Stator windings faults, Average absolute values, Fuzzy logic-based diagnostic approach

1 Introduction

Many countries are increasingly turning to wind power as a clean and sustainable energy source. Most wind farms use doubly-fed induction generators (DFIG), making it vital to monitor and detect faults in their electrical systems. These faults can harm performance, increase costs, and even halt electricity production. In this study, we focus on identifying electrical faults in wind power systems, such as stator winding short circuits and phase circuit openings. We use diagnostic techniques, including fuzzy logic, to improve the accuracy and reliability of DFIG monitoring and diagnosis [1]- [3].

2 Methodology

In this study, we focus on diagnosing short-circuit and phase-opening faults in a DFIG integrated into a variable-speed wind energy system. Each step of our methodology is detailed below. In our research, we employed a variable-speed wind system utilizing a grid-connected doubly-fed induction generator (DFIG). The DFIG is linked to the electrical network directly through the stator and via three-phase static converters to the IGBT through the rotor. The rotor-side converter manages torque and reactive power, while the grid-side converter controls voltage and power exchange. The system also includes maximum power point tracking (MPPT) for optimizing power extraction. For the initial step, we developed a model that describes the machine's behavior under normal operating conditions, thus establishing a reference point for our analysis. It's crucial to carry out this modeling in a way that clearly outlines the detection method. We then proceed by creating models to simulate short-circuit and phase- opening faults, enabling us to analyze the impact of these defects on the machine. Our methodology is based on utilizing fuzzy logic for fault detection and evaluation. This section provides details on how we implement this diagnostic method. The method involves acquiring stator currents and calculating their average absolute values to detect faults such as inter-

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turn short circuits and open-phase circuits in the stator windings. The diagnostic approach includes a fuzzy inference block for assessing the condition of the DFIG stator. The amplitudes of the stator currents and the stator's state are selected as input membership functions and fuzzy system outputs. The stator's status is represented by a linguistic variable, such as "Healthy," "Short-circuit," or "Open-phase". The input variables, which represent the stator currents, are also considered linguistic variables with values like "Very-small," "Small," "Medium," and "Big".

3 Results and Discussion

The simulation results in figures 1,2 and 3, obtained using MATLAB/SIMULINK, illustrate the output fuzzy value, which indicates the decision made. This value is within the range of CM = healthy [0 36], representing the healthy state's limits. In the case of an open stator phase, the criterion is CM = {open phase [63 100]}, similarly, for a short circuit of 30% of the windings, the criterion is CM = {short circuit [25 75]}. The method can provide real-time detection and localization of faults in wind turbines utilizing DFIG, solely based on phase currents.

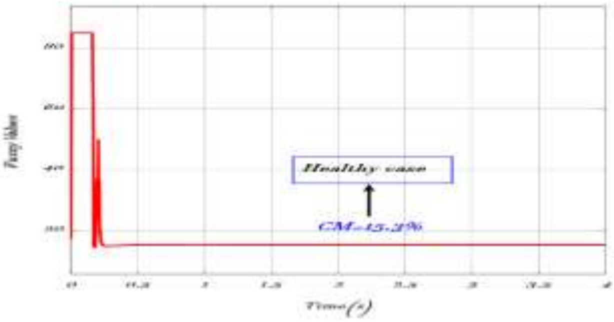

Figure 1: *Fuzzy output values under healthy case.*

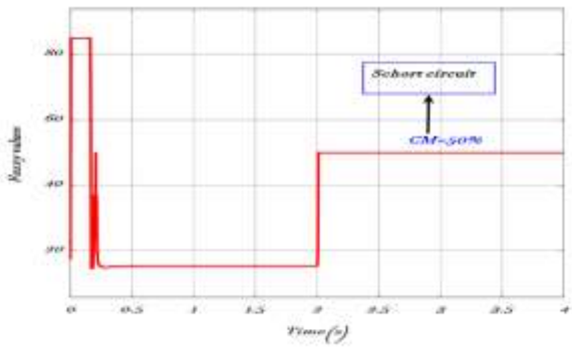

Figure 2: *Fuzzy output values in short-circuit case.*

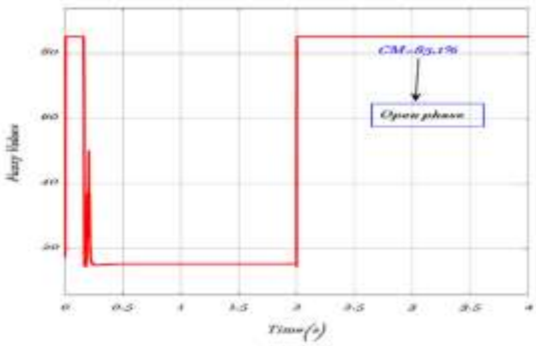

Figure 3: *Fuzzy output values in open phase case.*

4 Conclusion

In conclusion, the fuzzy logic-based diagnostic approach presented in this paper provides a dependableand efficient method for detecting faults in wind turbines utilizing DFIG. The simulations clearly showcase its effectiveness in real-time monitoring and fault prediction, which, in turn, can enhance the overall performance and lifespan of wind power systems.

How to Cite

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