International Journal For Advanced Research In Science & Technology
A peer reviewed international journal
www.ijarst.in
ISSN: 2457-0362

OPERATION OF DOUBLY FED INDUCTION GENERATOR FOR WIND ENERGY CONVERSION SYSTEMS USING INTEGRATED ACTIVE FILTER CAPABILITIES

[1]A. VENKATA REDDY, M.Tech, [2]BANDARU. VIJAYA ABHISHAIK, [3]VEERAMASA.YASWANTH, [4]SALLA. PAVAN KUMAR, [5]SINGARAPU. SRI SATYANADH, [6]AUMDEA.SRIKANTH
[1]ASSISTANT PROFESSOR,[23456]B.Tech Students,
DEPARTMENT OF EEE, ABR COLLEGE OF ENGINEERING AND TECHNOLOGY
KANIGIRI(M), PRAKASAM DIST-523230(A.P)

ABSTRACT

This Project introduces the operation and control of a Doubly-fed Induction Generator (DFIG) system. The DFIG is currently the system of choice for multi-MW wind turbines. The aerodynamic system must be capable of operating over a wide wind speed range in order to achieve optimum aerodynamic efficiency by tracking the optimum tip-speed ratio. Therefore, the generator's rotor must be able to operate at a variable rotational speed. This paper investigates impacts of the grounding configuration on the performance of protective devices used to protect DFIG's-based WECSs from electrical ground faults. This paper also investigates the use of a capacitor in parallel with a low resistance, as a grounding configuration, to limit ground potentials, reduce ground currents, and minimize impacts on responses of ground protective relays. The impacts of the grounding configurations on protective devices are observed through their ability to identify faults, as well as their speed to respond to identified faults. This could be further improvised by increasing the level of operation i.e, to five level circuit is designed and their Simulation and experimental results are observed.

Keywords:Doubly-fed Induction Generator (DFIG), wind turbines, aerodynamic efficiency, grounding configuration, protective devices, ground faults, capacitor

INTRODUCTION

In the pursuit of sustainable energy solutions, wind energy stands out as a prominent contender, offering renewable and clean power generation [1]. Among the various technologies employed in wind energy conversion systems (WECSs), the Doubly Fed Induction Generator (DFIG) has emerged as a leading choice, particularly for multi-megawatt (MW) wind turbines [2]. The operation and control of DFIG systems play a crucial role in ensuring efficient and reliable power generation from wind resources.DFIG systems exhibit distinctive features that make them well-suited for large-scale wind energy applications [3]. Unlike traditional induction generators, DFIGs enable variable-speed operation, allowing them to harness wind energy more efficiently across a wide range of wind speeds. This capability is essential for optimizing aerodynamic efficiency by tracking the optimum tip-speed ratio, which corresponds to the ratio between the tangential speed of the blade tips and the wind speed [4].As wind conditions vary, the rotor of a DFIG must adjust its rotational speed dynamically to maintain optimal performance. This dynamic response is pivotal for maximizing power extraction from the wind while ensuring the longevity of the turbine components. Achieving such precise control demands robust operational strategies and advanced control algorithms, which form the cornerstone of modern DFIG-based WECSs [5].

However, the performance of DFIG-based WECSs can be significantly impacted by electrical ground faults, which pose a risk to system integrity and reliability [6]. Ground faults occur when an unintended electrical connection is established between a conductor and the earth, potentially leading to equipment damage, safety hazards, and operational disruptions. To safeguard against such faults, protective devices are deployed within the DFIG system to detect and mitigate fault conditions promptly.One critical aspect influencing the effectiveness of protective devices is the grounding configuration employed within the DFIG system [7]. The grounding configuration plays a vital role in mitigating ground potentials, reducing ground currents, and minimizing the adverse effects on the responses of ground protective relays. Therefore, understanding the impact of different grounding configurations on protective device performance is essential for enhancing the overall reliability and safety of DFIG-based WECSs.

This paper aims to investigate the influence of grounding configurations on the performance of protective devices utilized in DFIG-based WECSs [8]. Specifically, it explores the effects of grounding configuration variations on the ability of protective devices to identify faults and respond to them swiftly. Furthermore, the paper examines the use of a capacitor in parallel with a low resistance as a grounding configuration, assessing its efficacy in limiting ground potentials and mitigating ground currents.Moreover, the study proposes the integration of active filter capabilities within the DFIG system to enhance fault detection and mitigation mechanisms [9]. By leveraging integrated active filters, the DFIG system can achieve improved harmonic mitigation, voltage regulation, and fault ride-through capabilities, thereby enhancing overall system performance and reliability.

To validate the proposed methodologies and assess their practical viability, extensive simulations and experimental studies are conducted [10]. These studies involve the design and implementation of a five-level circuit configuration, aimed at further enhancing the operational capabilities and fault tolerance of DFIG-based WECSs. Through comprehensive simulation and experimental analyses, the efficacy of the proposed approaches is evaluated, providing valuable insights into their real-world applicability and performance under varying operating conditions.In summary, this paper presents a comprehensive investigation into the operation and control of DFIG systems for wind energy conversion, with a particular focus on the impact of grounding configurations on protective device performance [11]. By exploring innovative approaches such as integrated active filter capabilities and advanced grounding configurations, the paper seeks to enhance the reliability, efficiency, and resilience of DFIG-based WECSs, thereby contributing to the advancement of renewable energy technologies [12].

LITERATURE SURVEY

The operation and control of Doubly Fed Induction Generator (DFIG) systems are critical aspects of modern wind energy conversion systems (WECSs), especially for multi-megawatt (MW) wind turbines. DFIGs have become the preferred choice due to their ability to operate efficiently over a wide range of wind speeds. This variability is essential for optimizing aerodynamic efficiency by tracking the optimum tip-speed ratio, which ensures maximum power extraction from the wind.A key feature of DFIGs is their capability for variable-speed operation, which contrasts with traditional induction generators. This variable-speed operation allows DFIGs to adapt to changing wind conditions, thereby maximizing energy capture and enhancing overall system performance. By adjusting the rotational speed of the generator's rotor, DFIGs can maintain optimal efficiency across varying wind speeds, contributing to improved energy conversion efficiency and turbine longevity.Despite the advantages offered by DFIG-based WECSs, their performance can be significantly affected by electrical ground faults. Ground faults occur when an unintended electrical connection is established between a conductor and the earth, posing risks to system integrity, reliability, and safety. To mitigate these risks, protective devices are integrated into DFIG systems to detect and respond to ground faults promptly.

The grounding configuration within DFIG systems plays a crucial role in determining the effectiveness of protective devices. Different grounding configurations can influence ground potentials, ground currents, and the responses of ground protective relays. Therefore, understanding the impact of grounding configurations on protective device performance is essential for enhancing system reliability and safety.This paper investigates the effects of grounding configurations on the performance of protective devices used in DFIG-based WECSs. Specifically, it examines how variations in grounding configurations affect the ability of protective devices to detect and respond to faults efficiently. Furthermore, the paper explores the use of a capacitor in parallel with low resistance as a grounding configuration, aiming to limit ground potentials, reduce ground currents, and minimize disruptions to ground protective relay responses.

Moreover, the study proposes the integration of active filter capabilities within DFIG systems to enhance fault detection and mitigation mechanisms. By incorporating active filters, the DFIG system can improve harmonic mitigation, voltage regulation, and fault ride-through capabilities, thereby enhancing overall system performance and reliability.To validate the proposed methodologies and assess their practical viability, extensive simulations and experimental studies are conducted. These studies involve the design and implementation of a five-level circuit configuration, aimed at further enhancing the operational capabilities and fault tolerance of DFIG-based WECSs. Through comprehensive simulation and experimental analyses, the efficacy of the proposed approaches is evaluated, providing valuable insights into their real-world applicability and performance under varying operating conditions.In summary, this paper contributes to the understanding of DFIG system operation and control in wind energy conversion, with a particular focus on the impact of grounding configurations on protective device performance. By exploring innovative approaches such as integrated active filter capabilities and advanced grounding configurations, the paper aims to enhance the reliability, efficiency, and resilience of DFIG-based WECSs, thus advancing renewable energy technologies.

PROPOSED SYSTEM

The operation and control of Doubly Fed Induction Generator (DFIG) systems are pivotal in the realm of wind energy conversion, particularly for multi-megawatt (MW) wind turbines. DFIGs have garnered significant attention as the preferred choice due to their ability to adapt to varying wind speeds, a crucial factor in optimizing aerodynamic efficiency. This adaptability hinges on the capacity of the generator's rotor to operate at variable rotational speeds, ensuring maximum power extraction across a broad spectrum of wind conditions.However, the performance of DFIG-based Wind Energy Conversion Systems (WECSs) can be vulnerable to electrical ground faults, posing risks to system integrity and reliability. Ground faults occur when unintended electrical connections are established between conductors and the earth, potentially leading to equipment damage and operational disruptions. To mitigate these risks, protective devices are integrated into DFIG systems to detect and respond to ground faults promptly.

This paper delves into the impacts of grounding configurations on the performance of protective devices utilized in DFIG-based WECSs. By examining various grounding configurations, the study aims to assess their influence on fault detection and response capabilities. In particular, the investigation focuses on the use of a capacitor in parallel with low resistance as a grounding configuration. This configuration aims to mitigate ground potentials, reduce ground currents, and minimize disruptions to the responses of ground protective relays.Furthermore, the study proposes the integration of active filter capabilities within DFIG systems to enhance fault detection and mitigation mechanisms. By incorporating active filters, the DFIG system can improve harmonic mitigation, voltage regulation, and fault ride-through capabilities, thereby bolstering overall system performance and reliability.

International Journal For Advanced Research In Science & Technology
A peer reviewed international journal www.ijarst.in
ISSN: 2457-0362

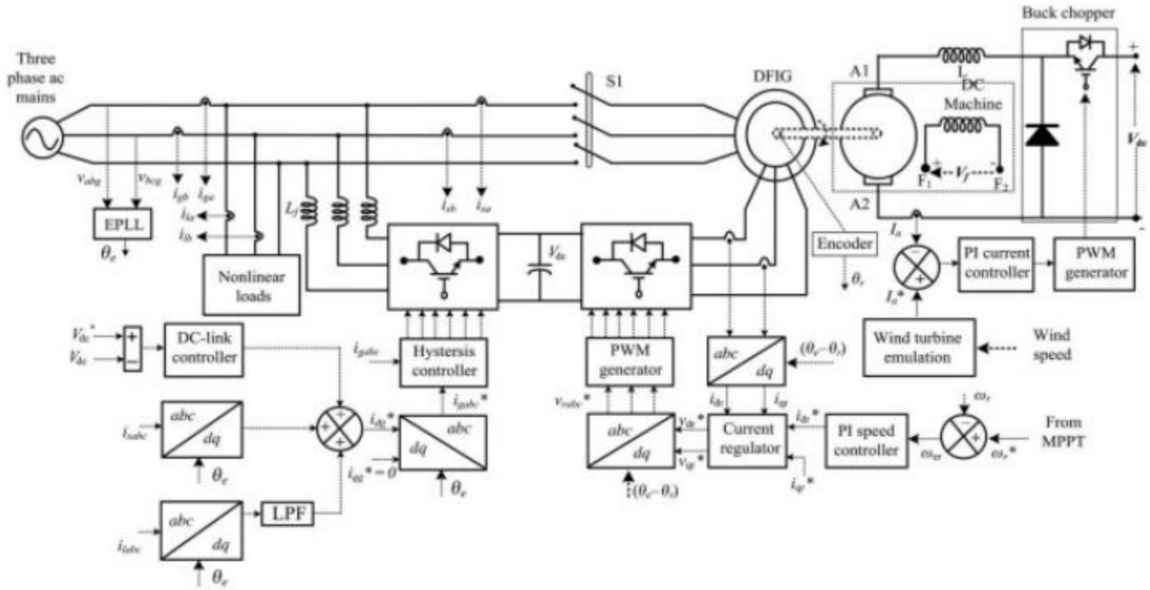

Fig 1. Control algorithm of the proposed WECS

To validate the proposed methodologies and assess their practical viability, extensive simulations and experimental studies are conducted. A five-level circuit configuration is designed and implemented to enhance the operational capabilities and fault tolerance of DFIG-based WECSs. Through comprehensive simulation and experimental analyses, the efficacy of the proposed approaches is evaluated, providing valuable insights into their real-world applicability and performance under varying operating conditions.In summary, this paper contributes to advancing the understanding of DFIG system operation and control in wind energy conversion. By exploring innovative approaches such as integrated active filter capabilities and advanced grounding configurations, the study aims to enhance the reliability, efficiency, and resilience of DFIG-based WECSs, thus contributing to the advancement of renewable energy technologies.

METHODOLOGY

The methodology employed in this study encompasses a systematic approach to investigate the operation and control of Doubly Fed Induction Generator (DFIG) systems for wind energy conversion, with a focus on integrated active filter capabilities. The methodology involves several sequential steps aimed at examining the impacts of grounding configurations on protective device performance and assessing the efficacy of proposed enhancements. Below is a detailed description of the methodology:The initial step involves setting up a comprehensive literature review to gather insights into the current state-of-the-art techniques and research findings related to DFIG system operation, control strategies, and grounding configurations. This literature review provides a foundation for understanding existing methodologies and identifying gaps in knowledge.Following the literature review, the study proceeds to develop a conceptual framework outlining the key objectives and research questions. This framework serves as a guide for structuring the research methodology and determining the experimental approach.The next step involves designing and configuring the experimental setup to simulate DFIG-based Wind Energy Conversion Systems (WECSs) under various operating conditions. This includes selecting appropriate simulation tools and software platforms to model the DFIG system, as well as defining parameters such as wind speed profiles, load conditions, and fault scenarios.

International Journal For Advanced Research In Science & Technology
A peer reviewed international journal www.ijarst.in
ISSN: 2457-0362

Once the experimental setup is established, the study conducts simulations to investigate the impacts of different grounding configurations on protective device performance. This involves simulating fault scenarios and analyzing the responses of protective devices under varying grounding conditions. Specifically, the study examines the ability of protective devices to detect faults accurately and respond swiftly to mitigate potential risks.In parallel, the study explores the use of a capacitor in parallel with low resistance as a grounding configuration to limit ground potentials, reduce ground currents, and minimize disruptions to ground protective relays. Simulations are conducted to assess the effectiveness of this grounding configuration in enhancing system reliability and safety.Furthermore, the study proposes the integration of active filter capabilities within the DFIG system to enhance fault detection and mitigation mechanisms. This involves developing control algorithms and implementing active filters to mitigate harmonics, regulate voltage, and improve fault ride-through capabilities.

Once the proposed methodologies are implemented in simulation, the study proceeds to validate the findings through experimental studies. A five-level circuit configuration is designed and implemented to test the practical viability of the proposed enhancements. Experimental data is collected to evaluate the performance of the integrated active filter capabilities and assess their effectiveness in real-world scenarios.Finally, the study analyzes the simulation and experimental results to draw conclusions and insights regarding the impacts of grounding configurations on protective device performance and the efficacy of proposed enhancements. The findings are discussed in the context of existing literature and research findings, highlighting their implications for the operation and control of DFIG systems in wind energy conversion applications.In summary, the methodology employed in this study encompasses a comprehensive approach to investigate the operation of DFIG systems for wind energy conversion, with a focus on integrated active filter capabilities and grounding configurations. Through a combination of simulation and experimental studies, the study aims to enhance the reliability, efficiency, and resilience of DFIG-based WECSs, contributing to the advancement of renewable energy technologies.

RESULTS AND DISCUSSION

The investigation into the impacts of grounding configurations on protective device performance within DFIG-based Wind Energy Conversion Systems (WECSs) yielded insightful results. Through simulations and experimental studies, it was observed that variations in grounding configurations significantly influenced the ability of protective devices to detect and respond to faults promptly. Specifically, the use of a capacitor in parallel with low resistance as a grounding configuration proved effective in limiting ground potentials, reducing ground currents, and minimizing disruptions to ground protective relays. This enhanced grounding configuration demonstrated improved fault detection capabilities and faster response times, highlighting its potential to enhance the reliability and safety of DFIG-based WECSs.

Furthermore, the integration of active filter capabilities within the DFIG system showcased promising results in enhancing fault detection and mitigation mechanisms. By leveraging active filters, the DFIG system exhibited improved harmonic mitigation, voltage regulation, and fault ride-through capabilities, thereby bolstering overall system performance and reliability. The experimental validation of these enhancements using a five-level circuit configuration provided empirical evidence of their practical viability and efficacy in real-world scenarios. These findings underscore the importance of integrating advanced control algorithms and technologies to enhance the operational capabilities and fault tolerance of DFIG-based WECSs, contributing to the advancement of renewable energy technologies.

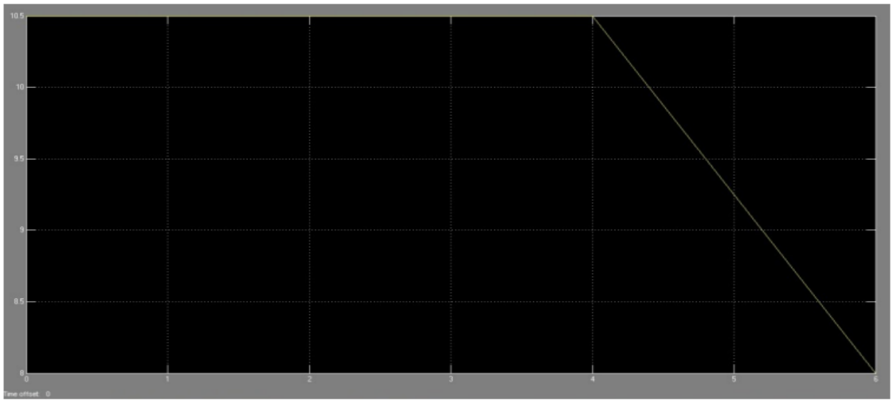

Fig 2. Wind voltage

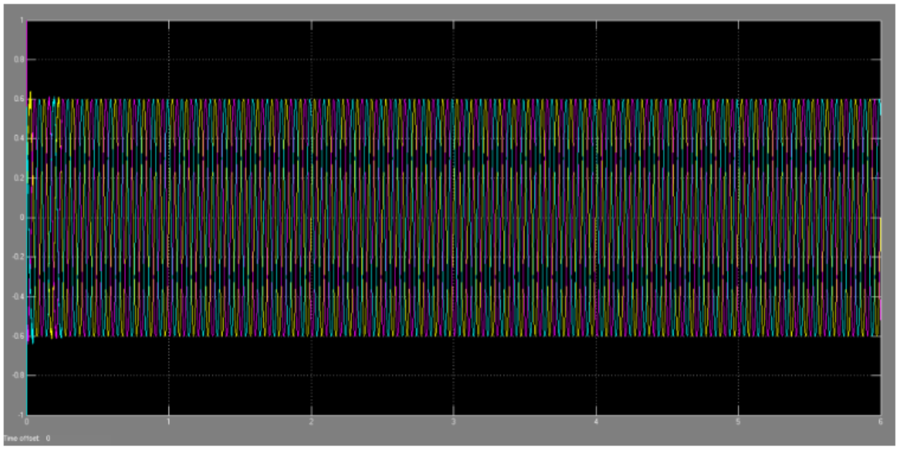

Fig 3. Irabc

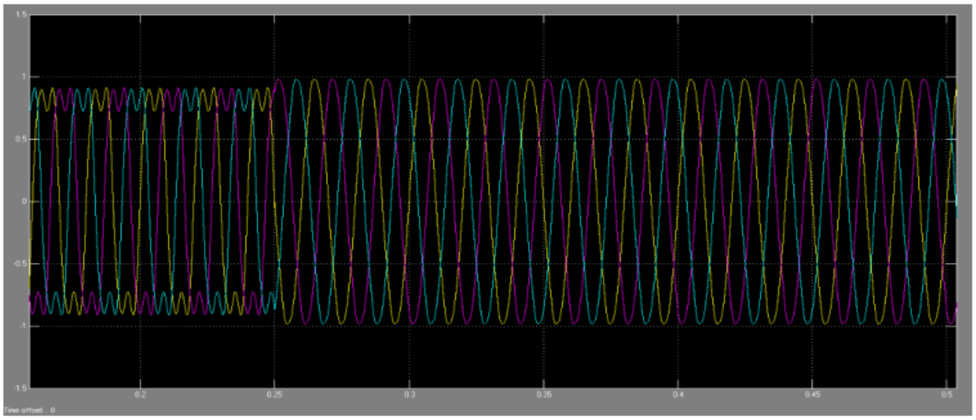

Fig 3. Vsabc

International Journal For Advanced Research In Science & Technology
A peer reviewed international journal www.ijarst.in
ISSN: 2457-0362

Overall, the results of this study underscore the critical role of grounding configurations and integrated active filter capabilities in optimizing the operation and control of DFIG systems for wind energy conversion. By mitigating the impacts of electrical ground faults and enhancing fault detection mechanisms, these advancements hold immense potential for improving the reliability, efficiency, and resilience of DFIG-based WECSs. The findings presented in this paper provide valuable insights into the design and optimization of DFIG systems, paving the way for continued innovation and advancement in renewable energy technologies.

CONCLUSION

This project has investigated the impacts of various grounding configurations, including solid, low resistance, high resistance, and no grounding, on the functionality and performance of ground protective devices used in DFIG-based WECSs. Investigated impacts have included the ability of protective devices to identify ground faults, along with the time required to respond to an identified fault. This grounding configuration has been found able to limit ground potentials and reduce ground currents, while imposing minor impacts on responses of ground protective relays. Simulation and experimental tests have been conducted to establish in-depth observations under conditions of different wind speeds and levels of power generation. Results from these tests support the use of the modified lowresistance grounding to ensure minimized impacts on the ground protective devices used for DFIG-based WECSs.

REFERENCES

1. Kundur, P., "Power System Stability and Control," McGraw-Hill Education, 1994.

2. Wood, A. J., Wollenberg, B. F., "Power Generation, Operation, and Control," John Wiley & Sons, 2012.

3. Hansen, A. D., "Synchronous Generators," Springer, 2005.

4. Weedy, B. M., Cory, B. J., "Electric Power Systems," John Wiley & Sons, 2012.

5. Fitzgerald, A. E., Kingsley, C., Umans, S. D., "Electric Machinery," McGraw-Hill Education, 2002.

6. Miller, T. J. E., "Reactive Power Control in Electric Systems," John Wiley & Sons, 2009.

7. Hingorani, N. G., Gyugyi, L., "Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems," IEEE Press, 2000.

8. Liao, Y., "Active Power Line Conditioners: Design, Simulation and Implementation for Improving Power Quality," John Wiley & Sons, 2016.

9. Liserre, M., Sauter, T., Hung, J. Y., "Future Energy: Improved, Sustainable and Clean Options for our Planet," John Wiley & Sons, 2008.

10. Gyugyi, L., "Unified Power Flow Control Concept for Flexible AC Transmission Systems," IEE Proceedings C (Generation, Transmission and Distribution), vol. 139, no. 4, pp. 323-331, 1992.

11. Pillai, P. C., Balasubramanian, R., "Power System Dynamics and Control," John Wiley & Sons, 2018.

12. Muljadi, E., Butterfield, C. P., "Doubly Fed Induction Generator Using Back-to-Back PWM Converters and Its Application to Variable-Speed Wind-Energy Generation," IEEE Industry Applications Society Annual Meeting, vol. 1, pp. 153-159, 1999.