A STUDY OF PERFORMANCE OF DFIG BASED MICROGRID SUBJECTED TO DISTURBANCES

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Abstract - The integration of wind energy into the electrical grid has become increasingly essential in our pursuit of sustainable and renewable energy sources. The research employs techniques to capture the complex dynamics of DFIG wind turbines, encompassing the rotor, drivetrain, and electrical subsystems. This analysis provides critical information for designing control strategies that enhance the stability and performance of grid-connected wind turbines. Furthermore, the inclusion of a detailed model allows us to investigate the mechanical aspects of the turbine. This holistic approach not only enhances our understanding of the system but also aids in the development of strategies to mitigate disturbance and improve the overall reliability of wind turbines. The findings of this study contribute to the optimization of grid connected DFIG wind turbines, making them more resilient and efficient in harnessing wind energy. As renewable energy sources continue to play a pivotal role in the global energy landscape, a comprehensive understanding of the dynamic behavior of wind turbines is essential for achieving a sustainable and reliable power supply.

Key Words: MCDM; AHP; TOPSIS; MOORA; HRES.

1. INTRODUCTION

Nowadays wind energy becoming the most significant one. DFIG is one of the systems used in wind energy in this system there are advantages as well as disadvantages one the disadvantage in this system one of the problems is occurring some disturbances in DFIG based micro grid system these disturbances are known as voltage dips and faults. when DFIG is excited by a rotor converter, during normal operation**.** When there is failure in power grid**,** the voltage of the DFIG drops suddenly, and a large transient voltage and current are induced in the rotor windings. And other is fault which is nothing but unusual condition in a transmission line for example like smoke, fire, sparking, etc. occurred is known as fault

Micro grids are the small network of electricity which bare used to supply electrical power to local users that is usually attached to a centralized national grid but is able to function independently. In light of growing environmental concerns, current and future microgrid systems are expected to feature substantial integration of clean energy sources. Within the knowledge of power systems, an immediate issue revolves due to it can trigger a series of interconnected issues and failures that can lead to more severe consequences, such as blackouts, unless protective actions are taken promptly [13], which can escalate into severe failures and blackouts unless swift protective measures are implemented in a timely manner. For these type of disturbances several existing methods are available for detecting in a transmission line by using signal processing algorithms, AI based models etc..[14]

The contributions of this study extend beyond theoretical analysis. They are simulated in MATLAB environment with implications for the design, operation, and maintenance of grid connected DFIG wind turbines. By elucidating the intricate interplay between electrical and mechanical components, we aim to provide valuable insights that can guide the development of innovative solutions for the wind energy sector. Ultimately, our research seeks to support the continued growth of wind power as a clean and sustainable energy source, making substantial strides towards a greener and more resilient energy future [13].

The majority of techniques employed in power system studies rely on physical modeling and analysis. However, as system uncertainty and complexity have grown, these traditional methods have become increasingly difficult to manage. Consequently, the utilization of AI techniques, characterized by their self-learning capacity and reduced reliance on mathematical models of physical systems, can offer viable and efficient solutions. Some of the models are [14]:

1)AI techniques

2)using AI for power system models

3)machine learning

In this several methods are proposed to protect the disturbances related to micro grids and for identification these type of faults in transmission lines and in dfig based micro grid systems

Proposed models for protecting the microgrid studies:

1) PSO and SVM method:

a) Particle Swarm Optimization (PSO):

PSO is a population-based optimization technique inspired by the social behavior of birds flocking or fish schooling. It's used to find the best solution in a search space by iteratively adjusting a population of potential solutions (particles) based on their fitness or objective function values.

Application in Power Systems:

- Optimal Power Flow (OPF)
- Unit Commitment:
- Distributed Energy Resources (DER)

b) Support Vector Machines (SVM):

SVM is a supervised machine learning algorithm used for classification and regression tasks. It works by finding the hyperplane that best separates data into different classes while maximizing the margin between them.

Application in Power Systems:

- Fault Detection and Classification
- Load Forecasting
- Anomaly Detection: SVMs
- Voltage Stability Assessment: SVMs can help assess voltage stability by analyzing system parameters and identifying regions of potential instability.

Both PSO and SVM have been applied successfully in power systems to address complex optimization, prediction, and classification tasks. They offer valuable tools for enhancing the efficiency, reliability, and resilience of power grids in the face of increasing uncertainty and complexity

2) A Recurrent Neural Network (RNN) is a type of artificial neural network specifically designed to handle sequences of data. In the context of power systems, RNNs can be applied for various purposes:

- Load forecasting
- Time series prediction
- State estimation
- Control and optimization etc.

2. LITERATURE SURVEY

Ensuring the reliable and safe operation of AC microgrids is crucial, but designing effective protection mechanisms is complex due to factors like operational modes, control strategies, and converter limitations. N. Hussain *et al.* [1] provided an overview of recent research and challenges in AC microgrid protection, covering fault detection, classification, coordination, and evaluating various techniques' pros and cons. A novel approach for change detection and fault classification in AC microgrids (μGs) with diverse operating modes is introduced by M. A. Jarrahi *et al.* [2]. It relies on a Teager-Kaiser energy operator-based analysis of a current-based signal (sum of squared three-phase currents), showing significant variations during change conditions, enabling fault phase identification. The method is validated through MATLAB/Simulink simulation and a laboratory test bench, demonstrating its accuracy and speed when handling both μG operation modes, and it's compared to similar methods for performance evaluation. Researchers are increasingly concerned about accurate fault detection and classification in microgrids due to its impact on transient response and system reliability. S. Rahman Fahim *et al.* [3] reviewed existing fault diagnosis techniques in microgrids, highlighting limitations, and introduces a novel discrete-wavelet transform (DWT)-based probabilistic generative model for precise fault diagnosis. The model, incorporating restricted Boltzmann machines (RBMs), demonstrates robust performance in fault detection and classification compared to other methods such as kernel extreme learning machines (KELM), multi KELM, and support vector machines (SVM).

R. Azizi *et al.* [4] proposed a Brown boost ensemble of intelligence-based methods for microgrid fault detection and classification, addressing limitations of conventional approaches dependent on current levels or impedance. Brown boost's advantage lies in its nonconvex optimization, making it robust to overfitting in noisy real-world data. The Hilbert-Huang transform is employed for signal processing and feature extraction, enhancing noise resistance. Validated on an IEC test microgrid, this approach offers ease of tuning, robustness, and applicability to imperfect data compared to traditional classifiers. Dharmapandit, O *et al.* [5] introduced a novel spectral energy differential protection scheme utilizing sparse Fourier kernel fast time-frequency transform for detecting, classifying, and locating faults in both grid-connected and islanded AC microgrids. The approach involves processing current samples to identify fault incipience and calculate spectral energy, successfully demonstrating fault detection, classification, and location across various operational scenarios in microgrids through extensive numerical experiments.

3. METHODOLOGY

The main process used in this paper involves the simulation of a DFIG wind farm which contains 4 wind turbine farms integrated to the utility grid. Numerous types of faults including but not limited to symmetrical faults and unsymmetrical faults. These faults are simulated in the MATLAB model which is then run on various test conditions to obtain the raw voltage and current signals from the given data. The signals are then passed through custom filter using the MATLAB editor which helps in finding the fault point and generates fault signal, full cycle, half cycle and quarter cycle for each kind of fault. This fault data is then passed through the Signal Energy Operator (SEO) to generate the parameters such as energy, entropy, standard deviation, mean and kurtosis

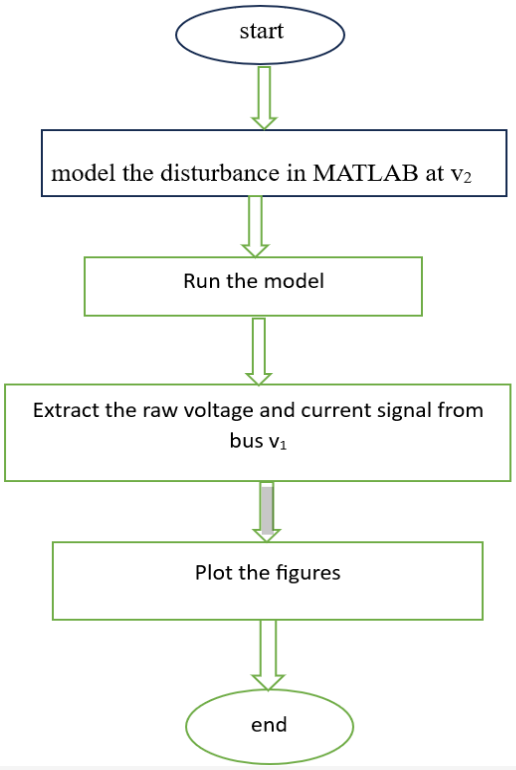

Figure 1. flow chart

The complete process of the fault analysis simulation is demonstrated in Fig. 1. In this model simulation, the parameters of the DFIG wind turbine farms used are as follows:

- Farm power rating = 9 MW
- No. of turbines in each farm: 6
- Generator type: Wound Rotor Induction Generator
- Nominal DC bus voltage: 1150 V
- Nominal mechanical output power: 1.5 MW
- Initial wind speed: 11 m/s

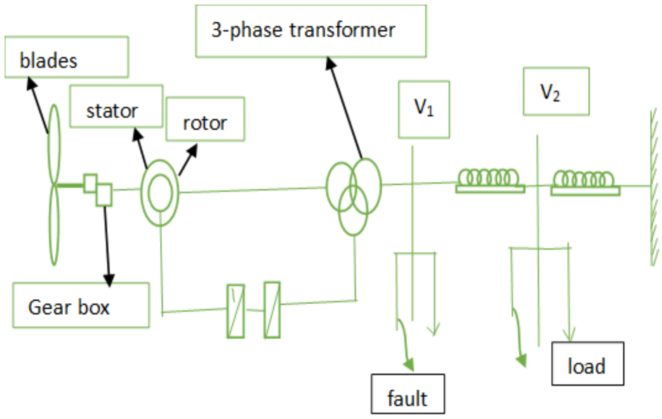

Figure 2: dfig structure

Above figure shows model of the dfig based micro grid system here fault injected at $V_2$and output collected at V_1.

4. RESULTS AND DISCUSSIONS

Disturbance simulated: -

The simulated output results are demonstrated in Fig. 2 & Fig. 3, showing the Voltage and current outputs at the receiving end of the Microgrid system respectively.in fig.2 shows the fault occur in 3 phase system and fig 3 shows that fault occur in single phase system

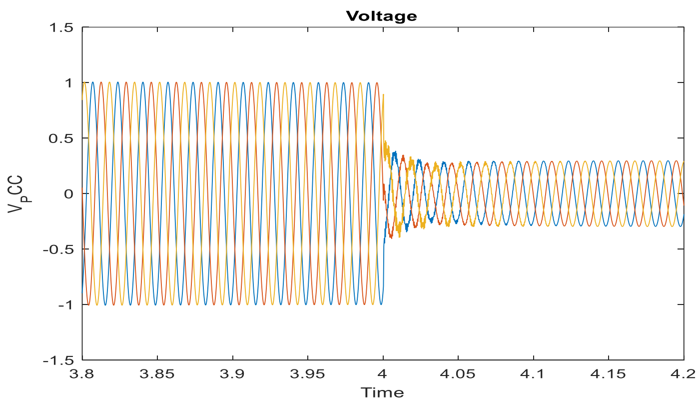

Fig. 2: Voltage at Receiving end

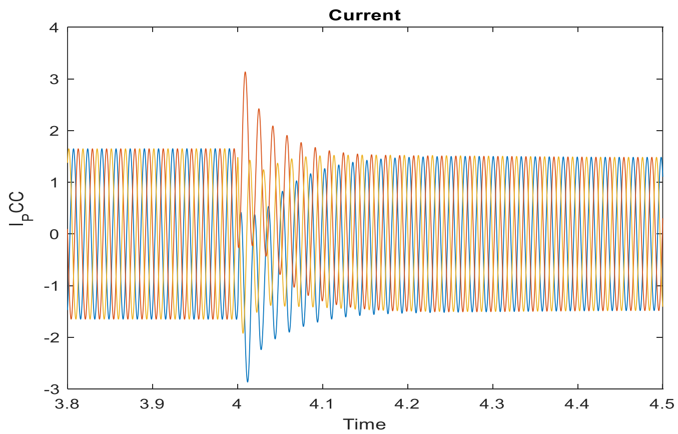

Fig. 3: Current at Receiving end

These outputs show that even though there is a disturbance in the transmissions system due to fault conditions, the fault is being detected and rectified within milliseconds, thus preserving the continuity of the supply as well as improving the transient stability of the system.

This simulation helps in implementing a robust and reliable control strategy for a grid integrated DFIG wind farm system, thus taking a large step towards a greener energy future.

An app is developed regarding this project for better understanding below figures are the reference for the app:

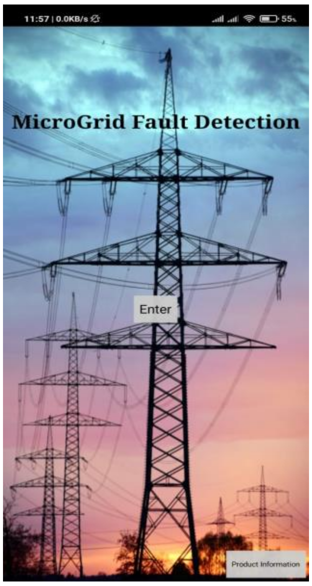

Fig. 4: starting of app page

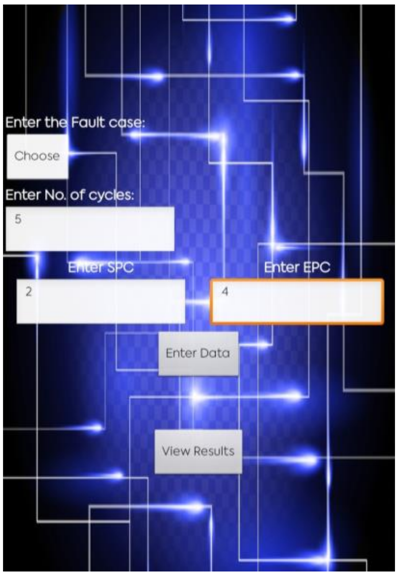

Fig. 5: entering the data page

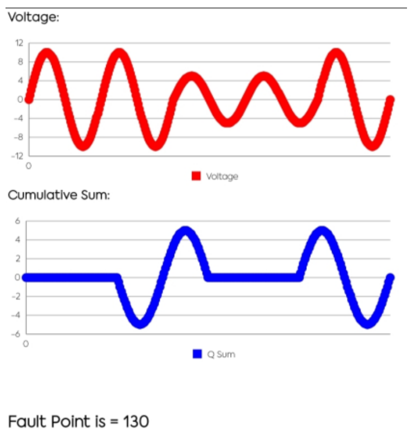

Fig. 6: output page

Above figures related to app developed. Firstly, download the app through APK file then install it. Later open the app and press the enter option which is appear on the screen refer fig 4 for reference. Then the display appears with some data first enter no of cycles and then enter SPC (starting point of cycle) and EPC (ending point of cycle) and then press enter option for better understanding refer fig 5, and press view results and on the display the results will appear according to data you enter refer fig 6.

5. CONCLUSIONS

In conclusion, the simulation results presented in Fig. 2 and Fig. 3 provide compelling evidence of the effectiveness of the proposed fault detection and rectification scheme within the microgrid system. These results not only showcase the voltage and current outputs at the receiving end but also highlight the scheme's robustness in the face of disturbances in the transmission system caused by fault conditions.

What stands out in these findings is the remarkable speed at which the system detects and rectifies faults, achieving this crucial task within milliseconds. This rapid response not only preserves the continuity of the power supply but also contributes significantly to enhancing the transient stability of the microgrid. It's a testament to the potential of advanced fault detection mechanisms in safeguarding the reliability of microgrid systems.

This simulation study holds immense promise for the practical implementation of a resilient and dependable control strategy tailored for grid-integrated Doubly Fed Induction Generator (DFIG) wind farm systems. By effectively addressing fault conditions and minimizing downtime, such a strategy can have a transformative impact on the reliability and sustainability of energy production.

As we strive for a greener energy future, the ability to swiftly detect and rectify faults in microgrids becomes increasingly essential. It not only ensures a continuous and stable power supply but also paves the way for greater integration of renewable energy sources into the grid. With these achievements, we take significant strides toward realizing a cleaner and more resilient power grid, setting the stage for a more sustainable energy landscape Figure 2.

Comparison of Rankings

Upon careful examination of the results, it can be concluded that Solar with Battery emerges as a robust choice across both TOPSIS and MOORA, making it a promising alternative for energy planning. These findings emphasize the importance of selecting ranking methods judiciously, taking into account the specific criteria and context of the energy planning process. Ultimately, Solar with Battery stands out as a superior option based on the results obtained, showcasing its potential to serve as an effective and sustainable energy configuration.

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