International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 10 Issue: 06 | Jun 2023 www.irjet.net p-ISSN: 2395-0072

Protecting the wind energy system from a short circuit (requirements - challenges - solutions)

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Abstract - *The urgent need for energy sources resulting from industrial growth and progress and support for the well-being of humanity has led to an increase in the interference of wind energy with traditional energy sources. Wind energy has its own characteristics resulting from its nature. Among these characteristics is its instability at a certain limit, as it is volatile, and this adds challenges to production, communication, and protection processes. This paper looks at this from a protection point of view and presents advantages, challenges, and some solutions to overcome the obstacles.*

Key Words: wind turbines, protection, Protection Challenge, Short circuit fault.

1. INTRODUCTION

Renewable energy technologies support the global trend towards preserving the environment and

Figure 1Displays renewable energy sources [8].

reducing pollution resulting from energy, especially wind energy, which is among the lowest-priced energies [2], To benefit from the advantages of wind energy and maintain the sustainability of its production, producers, and researchers are interested in the issue of protection [3], [4], The interest of producers and researchers is increasing with the increasing connection of wind energy with the power system, for protection many roles, including the speed of determining the fault situation and the speed of making the right decision in terms of severity and type, and who is responsible for clearing this fault [1]. The protection system also monitors the production system all the time in order to ensure the safety of the system, the safety of the energy produced, and the continuity of the energy flow process. A complete and effective protection system that protects wind energy systems of all kinds, but the scientific papers indicate the necessity of having a different system commensurate with the situation we want to protect and commensurate with the speed and size of the turbine [2]. All these added challenges and these challenges were clearer in wind energy systems. This study considers protection from an electrical perspective. Wind turbines are classified into large wind turbines and small wind turbines., according to the type of generator, or according to the place of installation [7].

2. Components of the wind power system:

2.1. Rotary blades:

They absorb energy from the wind and convert it into any other form of energy.

2.2. Gearbox:

It is present in some systems and other systems are not used, and the speed adjustment cycle is in a ratio between the rotary vane and the generator.

2.3. Generator:

It converts what it receives from mechanical energy into electrical energy.

2.4. Transmission lines:

Link between the generator and the load directly or between the generator and the network

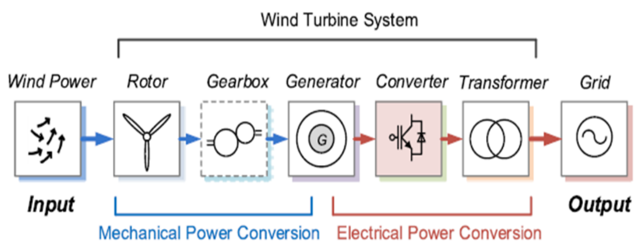

Figure 2Wind energy system diagram

2.5. Transformers:

They adjust the connection voltage poorly with the load or the network.

3. Classification of wind turbines by generator:

The kinetic energy absorbed from the wind is entered by the rotating blades and then transferred from it to the gear box, and from there it is transmitted to the rotating member in the generator, which converts the kinetic energy into electrical energy, and this electrical energy comes out from the generator to the load directly or to the electrical network. Research has indicated that the types of generators Wind turbines may differ according to a number of classifications.

- According to the communication interface between the generator and the network

- According to the method of dealing with wind speed

3.1. First: classification according to speed constant speed

- Limited variable speed
- Variable speed

3.2. Second: Classification of generators according to the interface with the network

3.1. Squirrel Cage Induction Generator.

3.2. Wound Rotor Induction Generator.

3.3. Double Fed Induction Generator, which is the most common and widespread.

3.4. Permanent magnet synchronous generator

4. The short circuit

One of the most common types of faults in electrical systems is a short circuit. Protective devices are therefore

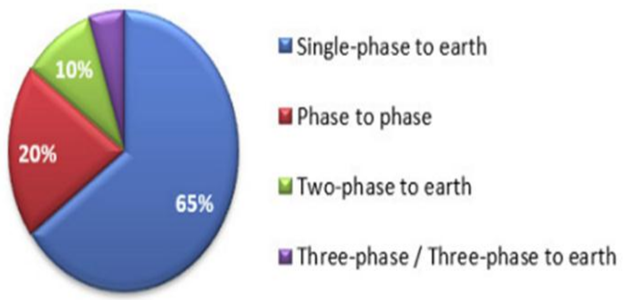

Figure 3Occurrence percentages of short circuits in the power system [9].

designed to protect against loss or damage to supply and consumer equipment in the event of an electrical short circuit.

A short circuit is an undesired connection between two conductors through relatively low resistance or between two or more circuit points, usually at different voltages [16].

5. Reason

5.1. High temperatures due to high currents (large load - fault)
5.2. The effect of high voltage on the insulator in a way that breaks the insulator.
5.3. The presence of moisture causes the insulation to weaken.
5.4. Exposure to stress or mechanical stress

6. Effect

6.1. Separate the source from the download locations.
6.2. Damage to equipment and devices
6.3. Exposure to thermal stress of equipment with repetition causes damage.
6.4. May cause fires.
6.5. May cause fatalities [16]

7. Protective device

In the event of a fault in the power supply network, rectification of the fault has the highest priority. Correct design and implementation of protective coordination therefore plays an important role. Relays and fuses act as fault indicators to protect the power grid.

7.1. Fuses and Relays:

Both fuses and relays are just the central sensors for all types of overcurrent protection systems in modern power systems. The fuse is an independent protection device that detects the fault itself and turns it off, and that happens by melting the fuse filament that cannot withstand the current in excess of the required limit, and this limit is called the threshold. You can use the fuse's characteristics to determine the appropriate fuse for a particular application. . Fast-acting or slow-acting fuses can be selected according to the type of load. But relays are just sensors. It detects an error and sends a trip command to a circuit designed to make the appropriate decision either to disconnect or connect, and it may operate according to a timeline.

7.2. Numerical Protection Relays:

A variety of protective relays of all kinds, including electromechanical numerical relays, solid state relays, microcontrollers, etc., are used to protect electrical power systems. Research indicates that digital relays have been widely used in electrical protection systems since the beginning of work on their modernization and development in 1985. This is due to the programmability of this type of relay.

It added modern features such as the small size resulting from merging a number of relays into one relay, the possibility of measurement, error detection, and event reporting data. This data can be used for trip analysis when faults are detected by protection relays in the power system. Through microcontroller programming, digital relays can provide the highest speed, reliability, selectivity, simplicity, efficiency, and cost-effectiveness in power systems. However, fuses are recognized as one of the most reliable applications for overcurrent fault detection and disconnection of devices in industrial power systems. Therefore, most researchers believe that the adaptive overcurrent system combines fuses and relays is a more cost-effective solution than relays or relay-based protection systems.

7.3. The Overcurrent Relay

The overcurrent protection has the same as the input signal obtained from a suitable current transformer. relay types. In these relays, when the input current is higher than the preset current value (threshold), the relay sends an output signal to the circuit breaker (CB), and disconnects. electrical circuit and remove power from the result of overcurrent. This is to work to protect the special components connected to the source of the fault. There are three main types of overcurrent protection used in power systems. Deterministic moment relays, fixed time relays, and inverse time relays. The most common type is the inverse time relay, which has the inverse property, the relay operates faster (less time) as the current increases. These types of relays are usually included in instantaneous current units and when the current reaches its upper limit of its magnitude, the relay is energized immediately, thus preventing damage to the special power components [4].

7.4. Directional overcurrent protection

As with overcurrent protection, directional overcurrent protection is used as either a primary protection or a backup protection. Despite the high reliability of directional protection, the nature of wind turbines has made it difficult to coordinate and adjust their settings due to dynamic changes in wind energy. Although directional protection is the cheapest and simplest, these dynamic changes affect its sensitivity and selectivity, which can lead to incorrect wind operations [5]

7.5. distance protector

Distance protector is mainly used to protect transmission lines. Research has revealed that different voltage limits generated by wind turbines affect the performance of distance protection. Therefore, it has been found that distance protection with fixed settings is not suitable for transmission lines associated with wind turbines. However, even with new and improved designs, internal failures still occur, and if there is an excessive time delay in the disconnect signal or a dead band in the protection, the failures can cause serious damage or generate power to repair the equipment. This can lead to long interruptions in the operation of the unit. Therefore, improper use of conventional functions may result in economic and material damages to consumers [1].

7.6. Protections using artificial intelligence.

In the future, intelligent machines will replace or complement human skills in many areas.
Artificial intelligence is becoming a popular field of computer science because it improves human life in many areas.

Research in the field of artificial intelligence has produced a rapidly growing technology called expert systems.

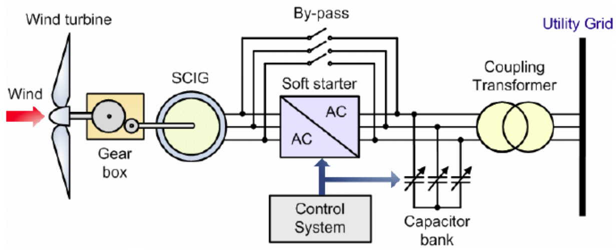

Figure 4Diagram of type A of types [10]

Expert systems are now widely used to solve complex problems in various fields such as science, engineering, economics, medicine, and weather forecasting.
In areas where artificial intelligence is used, it has the potential to improve quality and efficiency.

In the field of artificial intelligence, giving machines the ability to think conceptually and analytically.
Over the past 20 years, artificial intelligence technology has made great contributions in various fields.
Some papers in the field of artificial intelligence indicate that the protection that maintains system stability, dampens vibrations, and provides high-quality performance in networks depends on artificial intelligence techniques, and it was discussed protecting networks from error and how its artificial intelligence techniques can be used to solve common problems in the network [11]. Network fault analysis has a promising future, just like the field of power stabilizers. This technology and its applications can have a long-term impact on the protection of electrical systems, but it is a new technology and is still in the experimental stage, which indicates the need for more effort and research on its reliability [2].

8. PROTECTION CHALLENGE

Among the challenges in protection systems, short circuit is one of the most common types of system challenges. Therefore, protective devices are designed to protect against loss or damage to equipment on the part of the supplier and consumer in the event of a short circuit. As the power grid expands in the future, and connectivity to wind energy systems increases, planners must re-evaluate the design and upgrade of these devices through system analysis and short circuit testing.

Evaluating the contribution of wind turbines to the short circuit current of the system is very important to know the effect of these turbines and the loads. Short circuit fault can occur in network elements. The effect of wind turbines and their effect on short currents depends on the type of wind turbine generator. Consider Generator Type 1 and Wind Turbine 2 for detailed models of wind turbines and their characteristics. We find that they have almost the same electrical machining characteristics but type 2 has a slight difference that results from the added resistance of the rotor. Types 1, 2, and 3 have the highest short-circuit currents and occur at three-phase faults. 3 to 6 times the rated current. In type 4, the short circuit current has reached more than 110% of the rated current because the circuit has been disconnected from the mains by a transformer. The magnitude of the short circuit current at the coupling point depends on the number and type of wind turbines connected in parallel.

Power grids face a variety of protection challenges, including B. Relay underreach/reach issues due to different fault impedances due to high wind energy penetration. Accordingly, many protection schemes have been proposed, including adaptive logic program-based schemes, adaptive distance relay adjustment schemes, support vector machine-based schemes, data mining-based intelligent differential relays, wavelet, and Fourier transforms. Differential relay on the base. The magnitude of fault currents and the selection and coordination of protective devices are major challenges for wind-connected microgrids. Many solutions include adaptive overcurrent protection schemes, centralized communication with local backup schemes, fault distance estimation-based protection schemes, fuzzy reasoning system-based schemes, microprocessor-based schemes, oscillation frequency and transient power-based schemes, Parameter estimation, voltage-current-time reversal schemes are widely used protection schemes.

In addition, the choice of generator type for a wind farm, synchronous generator, induction generator, generator with converter interface also plays an important role in the design of a power grid protection system. Synchronous generators have long-term high-current stability characteristics, and the fault current of induction generators gradually decreases. The inverse is the short circuit current of the generator connected to the converter. limited to 2-3 times the generator's nominal current.

For low-voltage networks where renewable energy is present, especially for distributed generators, protection systems require special attention as they are subject to the new phenomenon of multi-directional power flows. Traditional [3].

In addition to the previous challenges, there is a challenge to add wind energy to protection, which is that wind energy is by nature variable in value and intermittent, and this challenge affects protection according to the type of protection used.

The research [4] indicates that the nature of wind turbine energy is intermittent, and this adds other challenges such as:

1- Poor coordination that may lead to wrong dismissal

2- The length of the separation time, which may increase the possibility of damage

3 - The difficulty of determining the optimal threshold for the value of the excess current, which may lead in some cases to a malfunction, but the separation has not been made [5].

9. Solutions

The research reviewed the protection equipment used to protect wind turbines and the challenges faced by this equipment, and then the research presents the solutions indicated by previous research to overcome these challenges:-

9.1. Adaptive Differential Protection

To meet the challenges posed by the nature of wind turbine energy, many researchers have published adaptive differential protection and it has been shown to be effective in the protection process. Depending on plant conditions and configuration, thresholds can be calculated online. Therefore, the method is applicable to virtually any energy system model and the impact of dynamic wind farm operation on protection is negligible. Threshold settings are designed considering the location of the obstacle and the angle of entry of the obstacle. First, the most effective fault among all possible faults is identified using a single variable objective function (fault location). Then the threshold setting with all possible parameters considers only single-phase ground faults. The method is tested against a standard power system model integrated into a wind farm and simulated using MATLAB R2016a software [6].

9.2. Adaptive overcurrent protection

Traditional protection schemes in distribution systems may be disrupted by the proliferation of distributed generation based on renewable energy sources. Such properties of wind turbines are stochastic due to the intermittent behaviour of wind dynamics. This causes the fault current level to fluctuate and cause overcurrent relay regulation problems. Minimize relay operating time. The proposed algorithm is tested in a modified IEEE-8 bus system with a wind farm to eliminate overcurrent relay misalignment caused by WD. To further prove the effectiveness of this algorithm, it is also tested on a typical substation integrated in a wind farm. Compared with conventional protection schemes, the results of the proposed scheme are promising in fault isolation as follows. B. Significantly shortens the total operating time of the relay and eliminates misalignment [7].

9.3. Adaptive Distance Protection

In this paper, we propose a remote protection method using local data from the transmission line connecting the playback stations. The proposed method determines the phase angle of the faulted loop current by determining the pure fault impedance of the regenerative plant at any time after the fault is detected, independent of the control system connected to the plant. Decide. calculation. Use this information to accurately calculate the resistance of the line to the point of failure. The performance of the proposed adaptive protection scheme was tested on a New England 39-bus integrated regenerative system using PSCAD/EMTDC simulation data and found to be accurate. Show superiority in comparative evaluation with conventional remote paging technology.

10. CONCLUSION

The research reviewed the importance of wind energy and what the global industrial community aims to develop for this sector. It also explained the seriousness of the short circuit error and the risks it might cause. It explained the importance of protection and indicated some of the protection techniques used andResearch indicated that the best solution to overcome the challenges added by the technology of wind systems lies in the air conditioning process, which represents the possibility of the protection relay changing its settings, and the process of changing these settings took several forms, some of which relied on prediction, and some of them were done by measuring wind speed and then resetting Adjusting the threshold according to the new data, and some relied on new equations added to relay systems to adjust the threshold according to the income of these equations, and explained some ways to solve those challenges.

ACKNOWLEDGEMENT

I would like to thank the supervisors, Dina Mourad, Faculty of Technology and Education, Helwan University, Cairo, EGYPT,
Tamer A.A.Ismail, faculty of technology at El Sahafa. ministry of higher education,
For what they gave me of help, advice, and guidance.

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