A Review on PV- Doubly Fed Induction Generator Wind Turbine Technology

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Abstract - Wind energy conversion systems are becoming very popular these days, and wind energy generating stations use wound rotor induction machines a lot. This is because wound rotor induction machines can be used with wind turbines with variable speeds. This makes it possible to get as much energy from the wind as possible. Also, using a Doubly Fed Induction Generator (DFIG) configuration with back-to-back pulse width modulated voltage source converters (VSC) is one of the best topologies that are currently available for wind power systems with induction generators. This topology works for both systems that are connected to the grid and systems that work on their own. In this work, a quick look at all of the control schemes for both the stator side converter and the rotor side converter is given in a stator flux-oriented reference frame, and the results are compared based on cost, efficiency, power consumption, and harmonics.

Keywords V2G and G2V three -phase inverter, MPPT, BSS,solar,DFIG

I INTRODUCTION

Since the need for power is always growing and fossil fuels are becoming harder to find, more renewable energy sources are being used. This could be good for the economy and the environment. WECS is a major source of electricity for power grids, and the amount of electricity generated by the wind is growing quickly every day. based on the results of the Global Wind Energy Report, The way they are set up is what makes the (HAWT) and the (VAWT) different types of wind turbines (WT) (VAWT). The HAWT, which has a variable speed mode, is the most useful and often-used type of WT. By changing how fast the rotor spins, the WT is able to get more energy out of it. This type of operation, where the speed of the wind can be changed, not only reduces the mechanical stress on the drive train, but it also makes the power output more even. With the help of an optional gearbox and a generator that is attached to the WECS, wind energy is turned into electricity. The WT comes after this. Even though other kinds of generators have been used, the most common ones are the (DFIG) and the (PMSG). In today's energy market, which is getting more and more competitive, it is widely agreed that simple, reliable, effective, and cost-effective WECS are very desirable. The nonlinear aerodynamic system, the complexity of the system's mechanics, and the fact that it has a number of faults all make it hard for the WECS to work. To make sure the WECS is safe, WECS must be able to stand with the grid if there is a momentary overvoltage at the point where the grid connects to the WECS. At the moment, a lot of research is being done on how WECS works, and much of it is focused on coming up with new ways to control it. Many researchers have looked at different parts of the WECS and written reviews. These studies have been shared. The grid systems that are connected to WECS are the focus of research because the effect of WECS in large ratings has a big effect on the grid. Still, the research points toward low-rated WECS that can be used by a single person. In contrast to the more common wind turbines with a fixed speed, which are the focus of Chapter 3, this chapter looks at wind turbines with a variable speed. In this kind of set up, comparisons are also made between direct-drive and indirect-drive turbines. 4, proposes a way to control the voltage and frequency of a stand-alone DFIG without a speed sensor. This is based on the root mean square (RMS) detection method. Evaluations that talk about power electronics topologies will not be taken into account. 5 just put out a full review of the four control methods that are most often used for (MPPT). MPPT into two groups based on how the power was measured: direct or indirect power controllers. They did a detailed analysis of the two groups, taking into account many important parameters during implementation. They did this by putting MPPT power controllers into two groups: direct and indirect. Tiwari and Babu's work was based on the structure of different pitch-angle-based controllers, from the older ones to the newer ones. Because wind power is hard to predict, power smoothing management is becoming more and more popular. Based on an analysis of simulation results, the kinetic energy of the inertia control method is a better way to smooth out power than pitch control with FLS and DC link control by d-axis current. 8 and 9 looked at the control techniques for the (RSC) and the (GSC), which are used in grid-interfaced WECS. They showed how (FOC), also called (VOC), are similar and different (DPC). Also, the performance of the VOC in relation to the different current controllers is talked about. Energy storage-based approaches that don't have energy storage systems installed next to each other do this to protect the WECSs in case of a line fault and keep the connection needed for low voltage ride through (LVRT). 10 They talk about how the chopper circuit-based fault protection method is becoming more popular because it is easy to use, can handle low voltage ride through (LVRT), and costs less because it doesn't need an energy storage system. By taking this step, the DC link capacitor is protected from the unwelcome changes in DC link voltage. The number 11 brought a review of control strategies for direct-drive PMSG-based WECSs that don't use position or speed sensors. The observers for the unmeasured signal were the main focus of this review. This kind of control can make the control more reliable when sensors go bad, which is important for lowering costs. On converter fault diagnosis, 12 topics were looked at. These included model-based and pattern-based approaches, as well as the problems. Chapter 13 talked about everything from whether or not WECS could work to how it could be used. It also talked about its adaptive and robust control. 14 gave up-to-date summaries of a wide range of WT control methods, along with assessments of how well they work based on research from as recently as 2016. Also, an internal faults review has been done, with more focus on model-based fault detection and control. 15 The review mentioned above did not, however, look into fault-tolerant control in more detail. On the other hand, research has made progress that goes beyond that.

The doubly-fed induction generator (DFIG) is now more popular and technologically advanced than any other type of wind turbine. To keep the grid from falling apart, DFIG must keep its connection to the grid working well and produce extra reactive power to allow voltage recovery when the grid voltage drops to between 0.2 and 0.9 pu[1-2]. In the absence of such safeguards, the reliability and safety of the power system could be compromised in the event of an accidental withdrawal of generators or rejection of loads during extreme voltage dips. Because of this, it is important to study and research DFIG reactive power compensation.

II RELATED WORK

Sobhy S. Dessouky et al. (2018) most important challenge in wind energy is maximising the quantity of power generated at any given wind speed. Several ways of mechanical sensor and system characteristic knowledge are necessary to monitor the maximum output power point. These tactics will increase prices in the actual world in order to increase maximum power point tracking. Using DFIGs and the MPPT control scheme, this paper proposes a way for obtaining the maximum power from a wind turbine based on perturb and observer approaches. A thorough model of DFIG system configurations is created using Matlab/Simulink. The simulation results demonstrate that the system operates effectively and that the suggested control mechanism increases wind power integration into the grid

Essam. H. Abdou et al. (2018) wind speed estimate (WSE) is used in the paper to extract the greatest. The wind speed is estimated using the rotor speed. The optimal shaft speed is chosen based on wind speed. An MPC system is also used to monitor rotor speed and estimate its optimal value in response to variations in wind speed. The simulation results revealed that the recommended MPPT technique may generate the optimal rotor speed for maximising output power

Xinglong Wang et al. (2017) Wind farms based on DFIG (Double-Fed Induction Generator) must be explored in high-altitude mountainous locations.The properties of wind farms in high-altitude mountainous locations can be explored first. Second, a short review of the simplified wind farm modelling technique is in order. In the third stage, a complex wind farm modelling approach based on PSS/E and a user-defined model is offered, together with temporal and geographical wind speed distributions. A case study comparing a complete model and a simple model was conducted on a Guizhou wind farm to assess the applicability of the three comparisons.

Parminder Singh (2014) In the past few years, alternative energy sources like wind power have been getting more and more attention. A DFIG is used for wind power. Wind turbines with DFIG must have stable voltage so that they can keep running without stopping even if the grid goes down. These wind farms must be able to hook up to the power grid directly. By changing the speed, frequency, and voltage of a DFIG-based wind turbine, you can control how much active and reactive power it puts out. By using the Simulink tool, Simpowersystem can look at how different DFIG operating conditions affect the output of the system. The vector control computing method is used to model and simulate induction machines in MATLAB/SIMULINK. In this study, the changes in torque, rotor speed, stator current, and rotor current on the rotor side of a DFIG are looked at. When looking at the grid-side converter, however, changes in voltage and current source, as well as changes in active and reactive power, can be seen. Once the mistake has been fixed, the control scheme puts the DFIG back to normal.

Preeti Sonkar et al. (2017) power sector has showed an interest in renewable energy sources in order to meet the ever-increasing demand for power. Wind energy is the fastest-growing renewable energy source, necessitating the usage of wind turbines to manage the frequency of the grid. Wind turbines are used for grid frequency adjustment utilising inertial control and droop control techniques. This article investigates the frequency response of a DFIG-based wind turbine for the ARMA wind speed model. The current situations have been simulated using MATLAB/SIMULINK. The results of the simulation suggest that wind turbines with inertial control and droop control can have a favorable impact on the environment

Xie Hua et al. (2018) system's frequency management need is increasing as a result of the increased penetration of wind power. Wind turbine control technique research is critical for primary frequency regulation. An inertia and droop control strategy for DFIG wind power is suggested based on the design of this study. To implement the control approach, a DFIG wind turbine model is created using RTDS. The wind turbine's simultaneous frequency tracking and efficient primary frequency regulation are proved by simulation results produced utilising the aforementioned control approach.

A**njali V. Deshpande et al. (2019)** Renewable energy sources are gaining pace and beginning to make a substantial contribution to the global energy mix as a result of increased power demand and the constraints imposed by traditional energy sources. Wind power plants are currently being created all over the world to supplement the regular grid due to technological improvements. As a result, wind power's contribution to the power system is growing at a quicker rate, making it vital to understand how wind power influences the system's features. which may be used to evaluate wind-integrated power systems. According to this article, a double-fed induction generator (DFIG) may be utilized efficiently for variable-speed wind power generation

Jin Ma et al. (2018) the usage of precise models is the only way to ensure the authenticity of a simulation. Modeling of (DFIG) for study of power system stability has attracted researchers' interest in recent years due to its extensive application in wind power production. Wind turbine manufacturers have constructed models that are not only difficult to grasp, but also proprietary and adapted solely to their own models. A variety of generic models that have been simplified are available. Among these, the model is the most often used for analysing the stability of power systems. Until recently, the model's validation has been based on limited real-world data or chosen simulated scenarios. As a result, due to a lack of systematic and theoretical evaluation of its validity, it is probable that the current-source based model may be improperly utilised in real engineering practises. This paper investigates the validity of the current-source model in the presence of both symmetrical and asymmetrical faults. Our practise of modelling and analysing .

Welcome Khulekani Ntuli (2022) In this piece analysed and compared: Fuzzy logic controller-based WECS with a voltage source converter (VSC) and a DFIG; fuzzy PID controller-based WECS with a VSC and a DFIG. The voltage/current or power out signals, as well as the dc-link voltage, are smoothed out to decrease settling time and overshoot/undershoot oscillations, hence minimising steady-state inaccuracy. By utilising the grid-side converter, the active and reactive can be brought back to their nominal levels. To keep the DFIG's active power output constant, the rotor side converter also controls the rotor speed. To achieve satisfactory system control, we employ the vector control method.

Shaomin Yan (2019) : In this research, a two-level optimal design was made to reduce the gearbox ratio and improve the economic value of the DFIG system in a DC grid. With the help of two voltage source converters, one on the rotor and the other on the stator, which connect the DFIG to the DC grid, the synchronous speed, current, and voltage of a DFIG system can be changed. In this paper, we get rid of the limitations of the AC grid and give a two-level optimal method for controlling the system current and generator poles while taking into account the costs of the whole system. With the first-level optimal technique, the poles of the generator are changed and the gearbox ratio is lowered. A second-level optimal method is also used to control the current in the system and lower the gearbox ratio. Lastly, simulations are run to test the system architecture's reliability.

Subinay Vajpayee et al. (2020) shows how a double-fed induction generator with phase-locked loop (PLL) control can help synchronise the grid in real time. (DFIG stands for "Double Fed Induction Generator") (DFIG). This article shows how not having a uniform voltage can hurt traditional PLLs that use dq conversion. All simulations and model building were done with PSCAD. Even though the grid voltage is symmetrical, the positive sequence component that is not symmetrical makes the PLL much more stable. The proposed method is fast and stable, making it perfect for use in wind turbines. It can also be used in DFIG's wind power system when the main grid is down. So, the system was made so that it could be used for both normal and unusual things. The system's reliability was greatly improved by adding a phase-locked loop (PLL).

PV-DFIG- From a topological point of view, a boost converter and a DC-DC converter connect the solar photovoltaic array to the DFIG-based WECS's DC link. But when a DC-DC converter is added to the grid-side converter, switching losses and costs go up. The people who wrote [15] showed that their wind-solar PV system with a BES can work on its own. A boost converter connects the DC link of the DFIG, which is powered by a wind turbine, to the solar PV array. But because it is directly connected to the DC link, the current going through the BES is not controlled. Also, microgrids that use DG, wind, and solar energy sources have been made and written about [16–18]. In [16], the authors talk about how to plan the BES's capacity for an island microgrid that is powered by wind, solar, and diesel. But the idea of making DG as fuel-efficient as possible hasn't been brought up yet. In [17], a wind-diesel microgrid for a fuel-efficient zone that stores energy in batteries was put to the test. But because the BES current is connected directly to the DC link, it can't be controlled. Also, connecting just one RE source makes it more likely that the vehicle will leave the fuel-efficient zone. Venkatraman et al. [18] showed a wind-solar-diesel microgrid that stores energy in batteries. But when developing the source and load controllers, the best way for DG to work was not taken into account. In a microgrid, the BES is very important when there is an imbalance between supply and demand. It also makes it easier to get the most electricity out of wind and solar power, especially when production is higher than demand. There have been a lot of studies on different maximum power point tracking (MPPT) methods, both for wind and solar, to get the most power from a given wind speed and amount of sunlight. [12],

DFIG Wind Turbine

Figure 1 shows how the DFIG wind turbine works on the inside and how its control system works. The main parts of the DFIG are a grid-side converter (GSC) and a rotor-side converter that are connected back-to-back (RSC). The RSC and GSC are what connect the rotor windings to the power grid. The stator windings, on the other hand, are what interface with the power grid. By cutting the rotor off from the power grid, the converters can handle 30% more power than the wind turbine 3. Because of this, the price of converters and the harmonic filter has gone down a lot. Also, because the converter is smaller, it loses less power and is more efficient. The fact that a DFIG wind turbine can change both its active and reactive power outputs stands out as one of its most important features (PDFIG, QDFIG, respectively). The control system in Fig. 1 can be used to control PDFIG and QDFIG separately. 1, which is based on a method called "vector control." This control system has three parts: the speed controller, the voltage controller, and the pitch angle controller. When used in this way, the main control goal of a DFIG is to stop the power system from oscillating. The results of the research show that the control in the RSC has a much bigger effect on damping the oscillation mode than the control in the GSC. Because of this, the RSC is a great way to stop power from going up and down. The speed controller can use the current going through the RSC's quadrature axis (iqr) to control the active power output. The voltage controller can use the current going through the RSC's direct axis (idr) to control the reactive power output. Both of these controls can be found on the RSC's output. Because the DFIG can change how much reactive power it puts out, it doesn't need reactive power compensation like a fixed-speed wind turbine does. This feature not only keeps the DFIG terminal voltage stable during steady state and grid disturbances, but it also saves money by getting rid of the need to install reactive power balancing devices.

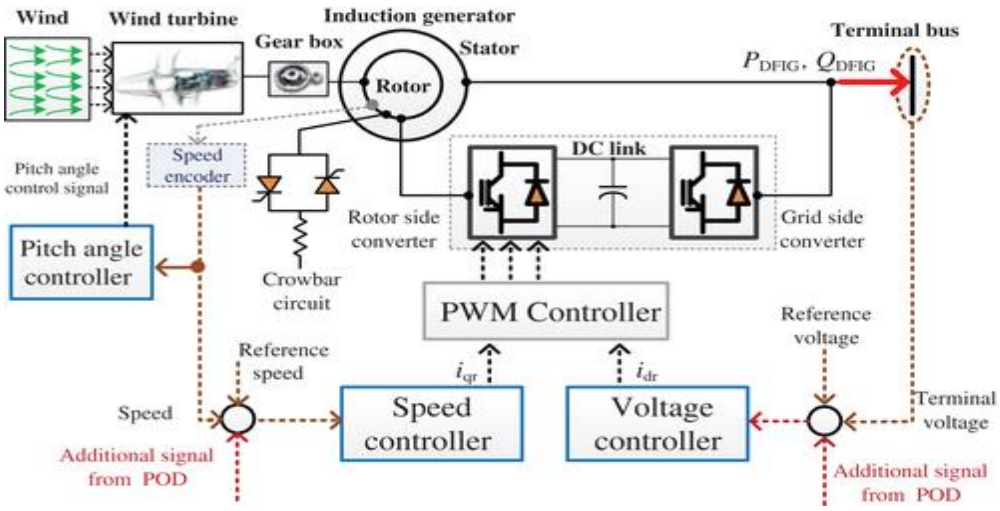

Fig DFIG wind turbine

Figure 1 shows that the rotor circuit is linked to the crowbar circuit, which is made up of two thyristors that don't work together and a resistor. The purpose of the crowbar circuit is to give a way around and restrict the amount of current that can pass through the rotor circuit, which is extremely high. Neither the rotor nor the power grid are severed in the event of an error, therefore rotor circuit protection can continue unabated. As a direct result of this, the DFIG wind turbine's ability to ride through faults (low voltage) has gotten a lot better. The resistance needs to be low enough so that the converter terminal doesn't get too much voltage. On the other hand, it should be high enough to limit the high current in the rotor. This is done to keep the rotor from getting too hot.

III Impact of DFIG Wind Turbine on the Power System Dynamic

A- Frequency stability

Frequency stability is the ability of a power system to keep the same frequency after a severe system upset that causes a big difference between power generation and power use. It depends on how well the load and the generation can be kept in balance or brought back into balance. The instabilities show up as sustained frequency swings, which, in the end, cause generators and/or loads to trip. The widespread use of DFIG wind turbines in power systems makes the frequency instability of those systems worse for a number of reasons that will be explained below.

1. The large output power fluctuations caused by DFIG wind turbines cause severe system frequency variation when the percentage of these turbines integrated into power systems increases. Because of this, With the right frequency relays in place, wind farms can be cut off from the grid. Frequency instability is worsened, and power oscillations become more noticeable, as a result of this. Due to the fact that the back-to-back converters severe the link between the power grid and the DFIG rotor, the DFIG rotor is unaware of any changes in the power grid's frequency.. Because of this, the large number of DFIG wind parks has a big effect on lowering the apparent system inertia. This not only speeds up the rate at which the frequency of the system changes, but it also lowers the point at which the frequency drops the most when generators are turned off. Because of what has just been said, this also means that the time it takes for the spinning reserve to make up for the difference in power will be shorter. This influence can be seen in the form of small power systems, isolated microgrids or weak grids, and isolated island grids like those found in Ireland and the United Kingdom.

B- Transient stability

According to Reference 12, transient stability is the ability of the power system to stay in sync even when there is a major disruption, like a short circuit. It depends on where the system was running before the problem and how bad the problem is. When there isn't enough synchronising torque, instability usually shows up as a change in angle that doesn't happen at regular intervals.

When the inertia of the DFIG rotor is disconnected from the power grid, not only does the effective system inertia go down, but the synchronizing torque goes down as well. This is because the traditional synchronous generators aren't used when there are a lot of DFIG wind turbines. After a system failure, these factors add to an increase in the total angular acceleration or deceleration of synchronous generators. The transient stability performance of the system is directly threatened by these possible events.

In previous work, the effect of large DFIG wind farms with less inertia on the level of transient stability margin reduction was studied. This was done so that researchers could learn more about how the two were linked. you have to run a time-domain nonlinear simulation under any initial operating conditions and faults that are put in. This can be done in any operating condition at the start. The study's results show that adding more DFIG installations has both negative and positive effects on transient stability. Time simulation is used to test a new transient stability index that uses sensitivity analysis. Here is where you can find the paper. The study shows that putting DFIG wind turbines in the right place makes the power system more stable during sudden changes. If DFIG wind turbines are put in places other than where they were first put, the stability margin gets worse.

The energy function method will be used to figure out how to solve these problems. To figure out how less inertia affects the system's transient stability, you need to use an energy function based on the potential energy boundary surface approach. With the direct computation of the critical energy and the critical fault clearing time, the study shows that DFIG wind turbines reduce the effective system inertia, which lowers the critical clearing time and transient stability margin of the system. This happens because the transient stability margin has been cut. Also, the method proposed for DFIG wind turbines to help with inertia can be used to estimate how much more inertia is needed when other machines cause the inertia to drop. According to the results of the study in Reference 22, which used the transient energy margin evaluation, however, research into the DFIG wind turbine's potential for enhancing the reliability of electrical systems in the face of unexpected fluctuations has been conducted. There are both static and dynamic parts to the DFIG converter controller. Modifying the RSC controller to take the DFIG terminal bus frequency as feedback allows for the input torque reference to be varied. This makes it possible for the active power output of a DFIG to be changed after a fault. The DFIG's fixed structure controller is in charge of making this change happen. By doing this, the power output of synchronous generators next to each other is changed, and the margin for transient stability is increased.

C- Small-signal stability

Reference 12 says that "small-signal stability" is how well the power system can handle small changes that could cause problems. How the system starts is very important. If there isn't enough synchronising torque, the rotor's angle can change because of a non-oscillatory disturbance. If there isn't enough damping torque, the rotor's oscillations can get bigger. The small-signal stability problem is linked to oscillation at frequencies between 1.0 and 2.0 Hz in the local plant mode and between 0.2 and 0.8 Hz in the inter-area mode.

DFIGs don't add any new oscillation modes to the system because they don't work in sync and are separated from the grid by converters. Their ability to change how modes of oscillation are dampened is limited, but it is possible through the four processes we will talk about below. But look at what's been going on in Texas 31, Minnesota 32, and Hebei province in the past few months.

D-Ancillary Services from DFIG Wind Turbine

As more and more DFIG wind turbines are connected to power grids, they will probably start to provide both active and reactive power. With the help of advanced wind forecasting and power smoothing techniques, modern power utilities can use DFIG wind turbines as a source of power that can be used when needed. So, DFIG wind turbines can help power systems. A lot of national grid codes for DFIG wind turbines also require that they offer auxiliary services. Here is a summary of what researchers have learned about how to control the frequency, voltage, and power oscillations of DFIG wind turbines.

E- Frequency control

DFIG wind farms can change the frequency of the grid in two ways: through inertia and power reserves. The first way to lower the frequency nadir at the start of a disturbance is to temporarily release the kinetic energy stored in the DFIG rotor. The second way is to keep putting the stored energy into a wind turbine that doesn't make enough power. So, DFIG wind turbines can only help control the primary frequency when they are not loaded. This is true even though their control effect is better than that of loaded turbines. To put it another way, DFIG wind turbines are run by following the curve that shows the highest power point. Wind power is going away because of this. DFIG wind turbines with power reserve control make it easier to control the frequency. This has been written about in a number of academic books and journals. The inertial control that was used in prior testing is now put through its paces.

F-Conventional inertial control of DFIG wind turbine

The maximum ROCOF loop can be used in ROCOF loop in conventional inertial control to retain the maximum ROCOF while eliminating the negative impact of the frequency rebound. The detrimental consequences of the ROCOF loop are mitigated as a result of this. The frequency nadir is raised, and more energy is lost as momentum before and after the frequency bounce than with conventional inertial control.

IV CONCLUSION AND FUTURE TREND

In this article, we talk about and analyse a number of ways to figure out how DFIG wind turbines affect the dynamic performance of power systems. These ways include frequency stability, transient stability, small-signal stability, and voltage stability. The DFIG's advanced control approaches for grid service support have been talked about. Power oscillation damping, frequency control, and voltage control are some of these control methods. Here is a short summary of what happened and what is likely to happen in the future:

Using DFIG wind turbines instead of synchronous generators lowers the effective system inertia and makes it harder to control the synchronising torques. This has a big effect on how well the power system responds to changes. Even so, the controlled output power of DFIG wind turbines can be used to help improve the way the electricity system works when it is combined with the right regulations.

When it comes to how they affect the frequency, DFIG wind farms not only make the frequency nadir worse, but they also make the ROCOF go faster. The latent inertia of DFIGs can be extracted using inertial control, which will help with both of these problems. The most important part of this control is figuring out how to change the controller gains so that more of the DFIG rotor's stored kinetic energy can be used. There is a big need for better inertial control technologies that can add more kinetic energy and keep things running smoothly.

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