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REDUCING FLICKERING: THE ROLE OF DFIG IN INDIVIDUAL PITCH CONTROL OF VARIABLE SPEED WIND TURBINES

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ABSTRACT: Grid-connected wind turbines are a source of power fluctuations that can create flickering during continuous operation due to wind speed variation, wind shear, and tower shadow effects. In order to examine flicker emission and related mitigation issues, this research provides a model of a variable-speed wind turbine with a double-fed induction generator. Individual pitch control (IPC) is indicated to reduce flicker output under a wide range of wind speeds. Individual pitch controllers (IPCs) are proposed, with designs dependent on the azimuth angle and generator active power of the wind turbine. The 1.5-MW upwind reference wind turbine model from NREL (National Renewable Energy Laboratory) is used in the calculations. Reduced generator active power via IPC, according to modeling studies, is an effective way for eliminating flicker in permanently functioning variable-speed wind turbines.

Index Terms—Flicker, flicker mitigation, individual pitch control (IPC), variable speed wind turbine

1.INTRODUCTION

In recent decades, there has been a major global emphasis on resolving energy constraint and environmental pollution, which has resulted in significant efforts in the adoption of renewable energy schemes, particularly those centered on wind power. The increasing integration of wind power into the electrical grid has created serious concerns about the quality of electricity. Flicker is important in the context of power quality because it has the potential to hinder the integration of wind turbines into both weak and moderately robust networks, especially when wind power penetration is high. The term "flicker" refers to the perceptual perception of an unstable visual sensation created by a light source that exhibits fluctuations in brightness or spectral distribution over time. Flicker is caused by voltage fluctuations caused by differences in load flow within the electrical grid. Wind turbines with variable-speed capabilities that are connected to the electrical grid exhibit power fluctuations while in operation. Voltage fluctuations in the network can cause flickering, which is caused by power fluctuations caused by a variety of variables including wind speed variations, wind shear, tower shadow, and yaw errors. The flicker emission of grid-connected wind turbines is impacted not only by wind power source conditions, but also by power system characteristics such as short-circuit capacity and grid impedance angle. The level of flicker emissions produced by various types of wind turbines varies significantly. The need for a flicker study on variable-speed wind turbines has developed as a result of the significant increase in wind power penetration, despite their superior performance in flicker emission as compared to fixed-speed wind turbines.

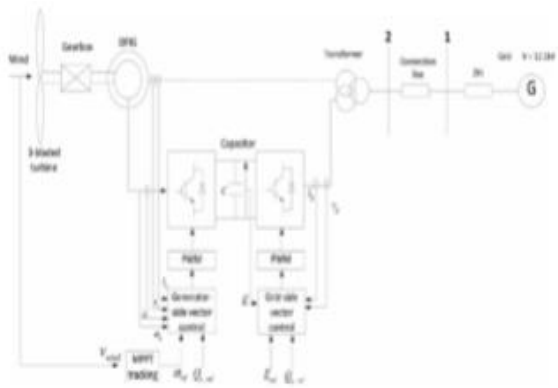


Fig. 1. Overall scheme of the DFIG-based wind turbine system.

2.EXISTING SYSTEM:

A wind turbine system with a doubly-fed induction generator (DFIG) consists of several key components, including the wind turbine, a gearbox, the DFIG, a back-to-back converter with a rotor side converter (RSC) and a generator side converter (GSC), and a dc-link capacitor positioned between the two converters. The FAST software program is used in this study to simulate the mechanical components and propulsion train of wind turbines. Within the model, Simulink blocks are used to represent the pitch and converter controls, doubly-fed induction generator (DFIG), and power system.

FAST

The National Renewable Energy Laboratory (NREL) created the open source code FAST, which is freely available to the public. The FAST software suite can be used to simulate horizontal-axis wind turbines with either two or three blades. The Blade Element Momentum theory is used to compute the aerodynamic forces on the blades, while an assumed technique is used to formulate the wind turbine's motion equations. Three-bladed wind turbine dynamics are distinguished by the use of a total of 24 degrees of freedom (DOFs). The models have both rigid and bendable components. The system's rigid components include the ground, base plate, nacelle, generator, and hub. The blades, shaft, and tower are all flexible parts. The use of the modal approach with fewer degrees of freedom (DOFs) to capture the fundamental properties of turbine dynamics leads in a significant improvement in FAST's computing efficiency.

3.PROPOSED SYSTEM:

The control objective of a variable-speed wind turbine powered by a doubly-fed induction generator (DFIG) varies depending on the wind speed. In low wind conditions, the primary goal of control is to maintain the optimal tip speed ratio, allowing maximum power extraction from the wind resource. The major purpose of the control mechanism in cases where the wind turbine's capacity is exceeded by available power at high wind speeds, resulting in possible system excess, is to ensure that the extracted power remains at its specified rated value. Vector control techniques are the most commonly used method for controlling a back-to-back converter in a wind turbine system. Figure 1 depicts two distinct vector control approaches, one for the RSC (Rotor Side Converter) and one for the GSC (Grid Side Converter).What are the stator's voltage and current? In this context, the variable "ir" represents the current flowing through the rotor, "vg" represents the grid voltage, "ig" represents the currents flowing through the Grid-Side Converter (GSC), "wg" represents the generator speed, and "E" represents the dc-link voltage. Ps ref and Qs ref are the stator active and reactive power reference values, respectively. Qr ref is the reference value for active power transfer between the grid and the Grid-Connected System (GSC). Eref is the reference value of the DC connection voltage. RSC's major goal is to improve wind power tracking by managing the electrical torque of Doubly Fed Induction Generators (DFIGs). A lookup table is used to calculate the reference value for the generator speed, ref, in order to achieve the best tip speed ratio.

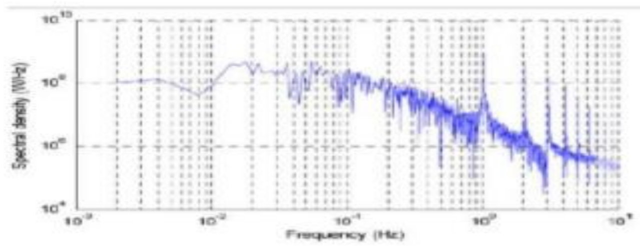


Fig.1The spectral density of the generator's output power is a measure of the power distribution across different frequencies in the generated signal.

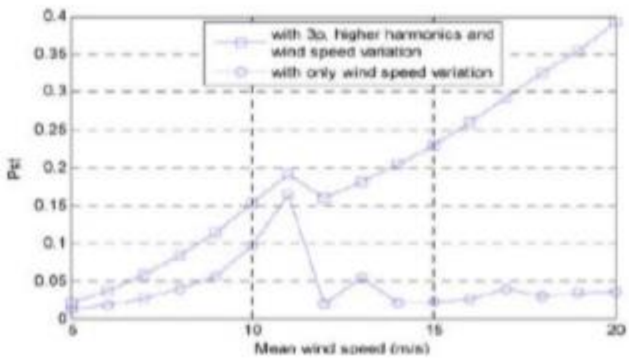
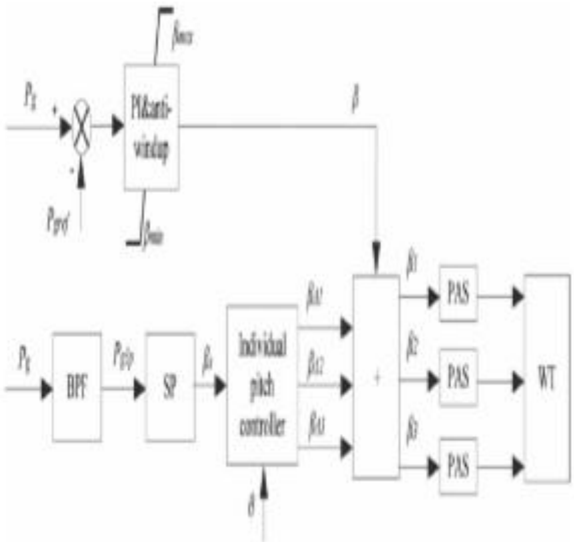


Fig2: The mean wind velocity, expressed in meters per second (m/s), is the parameter of interest.

INDIVIDUAL PITCH CONTROL FOR FLICKER MITIGATION

The primary goal of this section is to investigate flicker reduction approaches used in variable-speed wind turbines equipped with Doubly Fed Induction Generators (DFIG) during continuous operation, using the Individual Pitch Control (IPC) method. The principal source of flicker emission in grid-connected wind turbines during continuous operation is changes in the generator's active power output. The 3p and higher harmonics of the generator can be reduced to reduce flicker output, as shown in Figure 6. When the wind speed exceeds the designated wind speed, the pitch angle must be adjusted using a typical collective pitch control (CPC) system. This modification is critical in order to keep the output power at the specified level and keep the system from overloading. Typically, the 3p effect is not taken into account. The incremental rise of each of the three pitch angles is determined by the generator's active power and the wind turbine's azimuth angle. The purpose of this adjustment is to reduce the oscillation in generator power caused by the 3p effect. When the wind speed falls below the specified threshold, the primary goal of the wind turbine's control system is to achieve optimal power tracking by regulating the generator's electrical torque. In this particular region, pitch control is not used. The 3p impact can be mitigated by adjusting pitch angles while keeping an average value that is modest. To serve its intended purpose, the CPC output should have as little residual pitch as possible. This implies that a certain quantity of wind energy will be lost.



4.SIMULATION STUDIES USING IPC

The effectiveness of flicker suppression using an interphase power controller (IPC) is tested over a variety of wind speeds. The proposed IPC technique is used to simulate a variable-speed wind turbine with a doubly-fed induction generator (DFIG) and a back-to-back converter. The appendix contains the specifications for NREL's 1.5 MW wind turbine with Doubly Fed Induction Generator (DFIG).

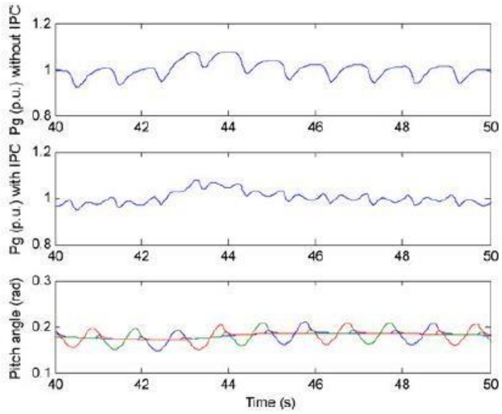


Fig.3. Short-term view of the generator active power without and with IPC, and individual pitch angles (high wind speed).

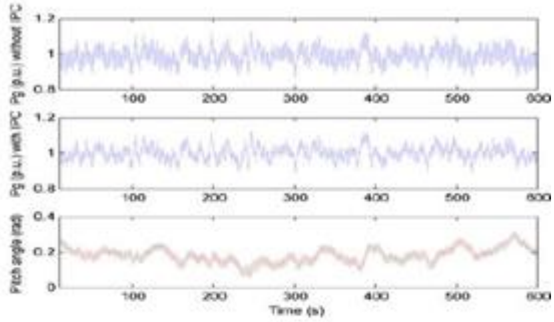


Fig.4Long-term view of the generator active power without and with IPC, and pitch angles (high wind speed).

Because of the negative impacts of wind shear, tower shadow, wind speed variation, and other reasons, one of the blades must reduce its pitch angle. As a result, the generator's active power fall will be less severe, resulting in a shorter range of power oscillation. The IPC approach was used to do a spectral density study of the generator's active power and its transmission into the grid, as shown in Figure 4. When the spectral density of generator active power without IPC is compared to the spectral density of generator active power with IPC, it is discovered that the 3p oscillation frequency component, which plays a significant role in flicker emission of variable speed wind turbines during continuous operation, is effectively attenuated with IPC implementation. As a result, IPC implementation may result in less distortion.

5.CONCLUSION

This study provides a way for tackling licker in variable-speed wind turbines equipped with MW-level Doubly Fed Induction Generators (DFIG) using Inter-Phase Controller (IPC) technology. FAST and Simulink are used to model the wind turbine system. The offered model is used to analyze and investigate flicker emission at various mean wind velocities. The International Panel on Control (IPC) proposes a breakthrough control strategy to reduce flicker emission. The Inter-Phase Controller (IPC) successfully mitigates the oscillation of the generator's active power, which is responsible for flickering at both high and low wind speeds. The simulation results show that using an interphase power controller (IPC) efficiently minimizes active power oscillation in the generator, reducing flicker in variable speed wind turbines during continuous operation.

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