

Optimized ANN-Based Dynamic Rotor Speed Control for Floating Offshore Wind Turbines in High Wind Speeds

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Abstract— The offshore wind turbines are exposed to wide range of fluctuating and unpredictable wind conditions. The dynamics of floating wind turbine platforms lead to increased mechanical stresses on the rotor of wind turbine. To solve these problems, a new approach has been developed using Artificial Neural Networks (ANN) for Dynamic Control of Rotor Speed for Floating Wind Turbines (FOWT). This control method combines pitch control using the angle of the blades and generator power control using a DFIG with three-phase PWM rectifier/inverter combination. ANN pitch control maintains the optimal rotor speed in real time and a PI controller maintains the voltage across the DC link, as well as controlling both active and reactive power. Simulation results show that currents and voltages stabilised very quickly and that the proposed controller achieved a rising time at 0.002 s and settling time at 0.05 s, demonstrating a very fast, stable, and efficient FOWT operation.

Keywords— FOWT, DFIG, ANN based pitch control, Dynamic rotor speed regulation, PWM power electronic control.

I. INTRODUCTION

Global warming and climatic pattern changes are two primary impacts of human activity caused by the over use of fossil fuels. Renewable energy, has the potential to reduce greenhouse gas emissions by providing sustainable and clean energy resource [1].

As the demand for clean and sustainable forms of energy increases, new technologies continue to develop rapidly in the area of offshore wind energy, particularly in areas of deeper water, where wind resources are generally higher, more pronounced, and more consistent. Floating Offshore Wind Turbines (FOWTs) represent an emerging solution for capturing wind energy from these areas, but there are challenges associated with the operation of FOWTs, such as platform motion, highly turbulent wind conditions, and rogue high-intensity storms [2].

High wind speeds pose a particular challenge to the stability of rotor speed; as wind speeds increase, the amount of rotation of the blades increase rapidly, creating a risk of

excessive mechanical stress and reducing turbine efficiency and safety [3]. Current control technology typically does not have the ability to rapidly respond to these changing conditions, therefore, advanced intelligent control systems are needed to enable turbines to operate as efficiently and effectively as possible while maintaining stability.

To overcome the challenges that FOWTs experience in dynamic situations, innovative control systems are required [4]. Traditional methods struggle with sudden changes in wind and wave conditions, resulting in inefficiency and potential damage. Innovative technologies, including as machine learning and real-time data analysis, it improve turbine performance, maintaining stability and efficiency while increasing the dependability of offshore wind power [5].

The proposed ANN based dynamic rotor speed control system provide a control strategy that enable FOWT operators to maintain both operational stability and electric generation efficiency while operating the turbine under the most severe wind-speed conditions.

A. Related works

CongCong et al (2021) [6] have developed the usage of SVM (Support Vector Machine) to detect events associated with wind turbines. It accurately classifies faults and/or anomalies that occur within sensor information and provides high levels of accuracy when performing pattern recognition. However, it require substantial processing resources and extensive adjustments to its parameters.

Bao et al (2023) [7] have proposed the enhanced active learning process that uses KNN provides for labelling the data being monitored to target efficiencies in identifying fault conditions within wind turbines. As KNN increases the accuracy level, it too has certain limitations. Among them, KNN consume considerable processing resources and is susceptible to overreacting to noise. Therefore, it must be treated with caution while processing the data.

Asghar et al (2024) [8] have implemented the RNNs (Recurrent Neural Networks) for controlling the blades of