# Review of Control Methodologies for Offshore Wind Farm Based HVDC Transmission System

Dhanvanti Rathore
M.Tech Scholar
Scope College of Engineering
Bhopal, Madhya Pradesh, India
dhanvi421@gmail.com

N K Singh
Assistant Professor
Scope College of Engineering
Bhopal, Madhya Pradesh, India
dannyk0809@gmail.com)

***Abstract*: Wind power is growing rapidly around the world and the offshore wind farm is currently seen as a promising solution to meet the growing demand for renewable energy sources. In addition to increasing the capacity of offshore wind farms and the distance between offshore wind farms and land, high voltage direct current (HVDC) is attractive. In addition, the DC grid may also be interested in connecting wind turbines at the collection level. It is possible to establish a DC grid for the offshore wind farm where the wind energy collection system and the power transmission system use DC technology. Existing grid codes for wind turbines mainly focus on air conditioning systems. Therefore, fault analysis in the DC network and the corresponding fault protection is required for the DC network.**

**Keyword -Wind Turbine Model, HVDC. DC, Grid.**

## I. Introduction

Frequency stability of the electrical system refers to the ability of an electrical system to maintain a stable frequency after a major system failure, resulting in a large imbalance between generation and load [1]. In the event of a sudden loss of significant power or a sudden increase in electricity demand, synchronous generators can extract kinetic energy (inertia behavior) and provide a primary control reserve to stabilize the system frequency. As offshore wind farms replace conventional power plants, wind farms like synchronous generators also need to help with frequency control. Offshore wind farms generally consist of wind turbines with electronic converters of variable speed and power. Due to the decoupling of the converters, these turbines are naturally free of inertia and have no primary fiscal reserve, as the wind cannot be controlled. However, efforts have been made to allow wind turbines with converter interfaces to introduce their rotational kinetic energy into the grid during frequency deviation through converter controls [4].

The energy reserve margin was also obtained by moving the turbines away from the optimal points at the expense of lower production. In order to integrate offshore wind farms into large scale onshore power grid, VSC HVDC transmission is more attractive and applicable than HVAC transmission system.

To transmit the same amount of power, DC cables have lower losses and no length limitations due to their immunity to load current. VSC-HVDC also offers other benefits such as fully controlled power flow and fast, independent control of active and reactive power.

However, due to VSC-HVDC decoupling, offshore wind farms would not be directly affected by onshore system disturbances. Decoupling would prevent offshore wind farms from reacting immediately to frequency fluctuations in the onshore AC grid. In the case of offshore wind applications, the contribution of VSC-HVDC to controlling the frequency of the power grid was examined.

### *A. Wind Turbine Model*

The general configuration and control diagram of the FCWT and its operating curve used in this document. The generator side converter controls the active power of the generator and maintains the generator stator voltage at the nominal value. At the same time, the grid-side converter controls the intermediate circuit voltage and the reactive power flow to the offshore AC rid. In the conventional control strategy, the active power reference Pref is only provided by a Maximum Power Point Tracking (MPPT) approach and the wind turbine does not react to grid frequency deviations.

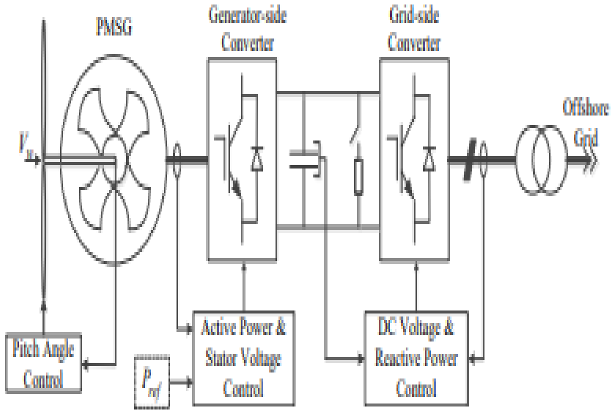


Fig.1 the FCWT and Operating Configuration

## II. LITERATURE REVIEW

Gang shi et al. [1] in this article, DC wind farms (DCWFs) with series connected DC wind turbines (DCWTs) are presented as a possible solution for offshore wind energy harvesting. The coupling behavior of series-connected DCWTs is described in detail. A possible limitation of wind energy when limiting the voltage of the wind turbine and its most important influencing factors are first calculated quantitatively. In the voltage limiting condition of DCWT with Energy Storage System (ESS), a decoupling control strategy is proposed to improve wind energy detection. It was found that the proposed control strategy could be a solution to wind energy restriction, which significantly improves the performance of series-connected DC wind turbines between the time scale in seconds and less than minutes.

Haibo Zhang et al. [2] This article presents the control strategy of a DC series offshore wind farm with an onshore modular multilevel converter (MMC). By connecting DC wind turbines in series, the HVDC transmission voltage level is determined without an offshore transformer and central conversion station, which indicates huge savings in investments in offshore wind farms. However, an imbalance in electricity generation in the wind farm or the bypass of a wind turbine can lead to spikes at the outputs of several wind turbines. This article first introduces the entire wind system. Next, the stationary analysis of the DC series offshore wind farm and the overvoltage phenomenon is described, leading to the proposal of the global control strategy. The detailed implementation of the overall control strategy using MMC occurs after a brief review of the MMC arm media model.

Tianyushi et al. [3] this study creates a detailed DC micro-grid model with the integration of a fully DC wind farm and other decentralized generation units (DGs). System components are the built-in dynamics of each part with their connections to a common DC bus. The study aims to implement coordination control between the general directorates in an operating mode both connected to the grid and in a deliberate island, the voltage of the common intermediate circuit being kept within an acceptable range by means of control commands.

Local micro-sources and global central control. The dynamics examined show that the coordination control scheme of each component can ensure voltage stability and normal power transfer. The proposed scheme would be a viable option for a sustainable application of DC microarrays.

Julius K Mwaniki et al.[4] This article summarizes the different solutions to the DFIG WECS challenges, including peak point monitoring, common-mode voltages, subsynchronous resonance, losses, modulation, power quality and errors. These are aspects of the DFIG WECS that are of paramount importance to network operators and potential investors and can also be an introduction for newcomers to the current field of study. Dual Power Induction Generator (DFIG) wind energy conversion system (WECS) has many advantages, which is why many have been installed so far. The operation of DFIG WECS is of great concern under both fixed and fault conditions as it affects network performance.

Marouane El Azzaoui et al.[5] This text explains the modeling and control of a Dual Power Induction Generator (DFIG) with a turbine feeding the AC grid. First, a model of the turbine is presented and then the MPPT (Maximum Point Tracking) control strategy of the induction generator with double the power. The technological development associated with the wind industry has led to a generation of variable speed wind turbines that offer many advantages over fixed-speed wind turbines.

Andrés Peña Asensio et al. [6] This document explains the planning and analysis of a voltage and frequency control (VFC) strategy for Full Converter (WECS) systems that support Full Converters (FCs) and their applicability for power supply. 'an isolated load. When supplying an isolated load, the role of the back-to-back converter within the FC must change from an application connected to the network. The voltage and frequency are determined by the FC network converter (LSC), while the generator side converter (GSC) is responsible for maintaining a constant voltage in the intermediate circuit.

The proposed VFC is fully modeled and a stability analysis is performed. The operation of the WECS within the proposed VFC will then be simulated and tested on a test bench in real time to demonstrate the performance of the VFC for isolated operation of the WECS.

Peiyuan Li et al. [7] this paper suggests the DC bus optimization control strategy in DFIG wind turbines with an influence converter (CSC). In CSC based systems, converter losses depend on DC bus current, so it is important to mitigate them. The direct current is chosen because it is the highest value of the rotor side converter current (RSC) and therefore of the line side converter current (GSC). Detailed control strategies are suggested for an optimal DC link converter. The simulation results confirmed the validation of the DC bus optimization control strategy.

## III. HVDC System

HVDC technology is an efficient and flexible method of transmitting large amounts of electricity over long distances via overhead lines or underground / submarine cables. There are mainly two types of HVDC transmission technologies. The first is the classic HVDC transmission system based on current converters with natural switching thermistors. It can be seen that conventional HVDC transmission system can obviously withstand short circuit currents, as DC inductors limit current in the event of a fault. The other is the new HVDC transmission with Self-Commutated Voltage Source Converter (VSC) with pulse width modulation. The VSC-HVDC drive system is becoming more and more attractive and is labeled by ABB with the name "HVDC Light" and by Siemens with the name "HVDC Plus". VSC HVDC technology uses insulated gate bipolar transistors (IGBTs) that can cut currents so that no active switching voltage is required. VSC HVDC transmission does not require a strong offshore or onshore AC grid. Furthermore, the active and reactive power of the VSC HVDC drive system can be controlled independently of each other, which reduces the need for reactive power compensation and can contribute to the stability of the AC grid [8]. Furthermore, thanks to the use of IGBT semiconductors, the VSC-HVDC transmission system can have a high switching frequency and reduce the harmonic content of the system, resulting in a reduction in the filter size required on the AC side.

## IV. MMC FOR HVDC

The MMC configuration is a new multi-level configuration that Siemens introduced in HVDC applications last year. The MMC consists of six converter arms, each of which includes a large number of SMs and a series-connected converter reactor.

The transducer arm acts as a controllable voltage source that is generated by a number of identical but individually controllable SMs to generate a large number of discrete voltage levels that form an approximate sine wave with adjustable voltage across the AC connection. With the converter reactor in each arm, the effects of errors inside or outside the converter can be reduced. Consequently, MMC technology offers significant advantages for HVDC transmission systems.

## V. HVDC System For DC Grid

The HVDC transmission system consists of an offshore station, transmission cables, and a land station. In the offshore station, the offshore converter is used to collect the DC clusters and convert the DC voltage from the collective voltage level to the transmission voltage level. In the ground station, the direct current is converted into alternating current and fed into the grid into alternating current.

the HVDC transmission system in the DC network differs from the existing HVDC transmission system where AC / DC or DC / AC power conversion is used at each point of the HVDC transmission system. HVDC transmission system configuration is therefore required for the DC grid, as shown in Figure 2, and a DC / DC converter must be developed for the offshore converter in the DC grid.

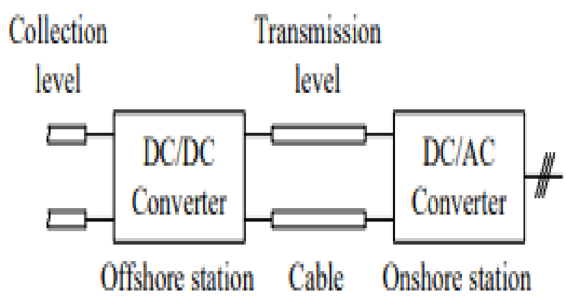


Figure 2 Block diagram of HVDC transmission system in the DC grid.

## VI. DC-GRID Layout

The DC / DC converter is installed in each wind turbine. The collective voltage level can be set as high voltage, which can reduce the cable loss collectively. The intermediate circuit voltage in the wind turbine can be controlled, whereby the reliability can be effectively increased and the system performance can be improved at the expense of the additional DC / DC converter in the wind turbine. There is only one DC / DC converter in the offshore station. The collective level voltage is the intermediate circuit voltage of the wind turbine, which is normally only a few kilovolts (kV). Particularly in large offshore wind farms, there may be a high current in the collection system, which may have a high demand for DC cables. If the DC / DC converter is present only in each wind turbine and the DC / DC converter is removed from the offshore station, the DC / DC converter in each wind turbine would raise the intermediate circuit voltage of the wind turbine to the transmission voltage level, which is high. Necessity of the wind turbine.

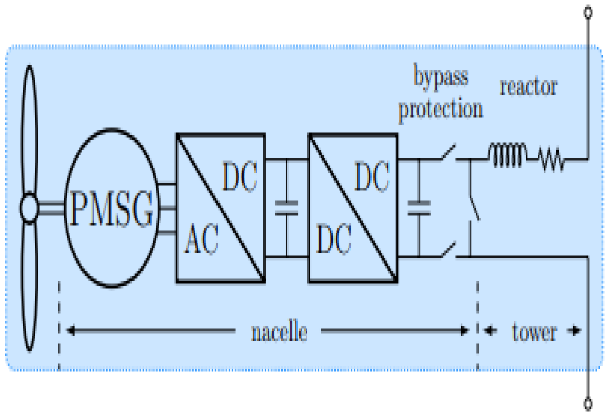


Fig. 3 DC Series wind turbine configuration

## VII. CONCLUSION

A direct current network for offshore wind farms is being studied, with particular attention to planning and control. The DC grid of offshore wind farms is different from the existing offshore wind farm. In the DC grid, the wind turbine output is DC and not AC, and the wind turbine can be integrated directly into the DC collection system. In addition, the offshore converter in the direct current network is a DC / DC converter for raising the DC voltage collectively to the DC voltage at the transmission level. Due to the mature technology for the wind farm with an AC grid, the DC grid structure for the offshore wind farm is similar to the wind farm structure with an AC grid. The wind turbines in the offshore wind farm are connected to certain groups of the DC distribution system. And then these clusters are collected in the offshore station and the DC level is raised to the transmission level from the offshore converter.

## REFERENCE

[1] Gang Shi, XuCai "Decoupling control of series-connected DC wind turbines with energy storage system for offshore DC wind farm"DOI: 10.1109/PEDG.2016.7527064Conference: 2016 IEEE 7th International Symposium on Power Electronics for Distributed Generation Systems (PEDG)

[2] Haibo Zhang, Diana Florez "Control strategies of a dc based offshore wind farm with series connected collection grid"April 2016DOI:10.1109/ENERGYCON.2016.7514062

[3] Tianyu Shi, Libao Shi "Operation and coordination control of a DC micro-grid incorporating all-DC wind farm"The 6th International Conference on Renewable Power Generation (RPG) 19–20 October 2017

[4] Julius Mwaniki, Hui Lin "A Concise Presentation of Doubly Fed Induction Generator Wind Energy Conversion Systems Challenges and Solutions" Volume 2017, Article ID 4015102

[5] Marouane El Azzaoui, HassaneMahmoudi "Modeling, Control and Analysis of a Doubly Fed Induction Generator Based Wind Turbine System: Optimization of the Power Produced" wseas transactions on power systems E-ISSN: 2224-350X Volume 12, 2017

[6] Andrés Peña Asensio, Santiago Arnaltes Gómez "A Voltage and Frequency Control Strategy for Stand-Alone Full Converter Wind Energy Conversion Systems" 26 January 2018; Accepted: 20 February 2018; Published: 25 February 2018

[7] Peiyuan Li ; Jianwen Zhang "DC bus current optimization control strategy in DFIG wind power systems with current source converter" 29 Oct.-1 Nov. 2017 DOI: 10.1109/IECON.2017.8216176.

[8] Z. Chen, Y. Hu and F. Blaabjerg, "Stability improvement of induction generatorbased wind turbine systems," Renewable Power Generation, IET. Vol. 1, pp.81-93, March 20017.