DFIG based Wind Energy Conversion System with Fault Ride through Technique

Shikha[1], Dashrath Kumar[2]

[1]*PG Student [Power System], Dept. of EEE, Maharishi University of Information Technology, Lucknow, U.P., India 1*
[2]*Assistant Professor, Dept. of EEE, Maharishi University of Information Technology, Lucknow, U.P., India 1*

Abstract - *In this article, the ability of doubly fed induction generator based on wind energy conversion system to remain connected through power system disturbances with fault ride through technique is discussed. it represents Doubly-fed electric machines are basically electric machines that are fed with ac currents into both their stator and rotor windings. Most doubly-fed electric machines in industry today are three-phase wound-rotor induction machines. Fault Ride through (FRT) is a mechanism by which the wind energy conversion system can be connected to the system during the voltage dip. This is achieved by either hardware or software implementation on the converter of rotor side and grid side which will prevent the converter from tripping and thereby provide uninterruptible operation to the DFIG during severe voltage faults. An analysis of different FRT control strategies has been carried out in this paper.*

Key Words: WECS, doubly-fed induction generator (DFIG), fault ride through (FRT).

1. INTRODUCTION

According to the numbers and studies talking about start entering the circle of running out of conventional energy and fossil fuels of petroleum and its derivatives, and due to the increasing of CO2 emissions, the frantic search comes by countries and companies, scientists and researchers to obtain so-called "alternative energy", or renewable and clean energy. It is forecasted that the cumulative wind capacity growth rate will be between 11% - 16% and the cumulative installed wind capacity will reach about 666 GW in the 2019. According to the global wind energy outlook, by green peace international and the global wind energy council (GWEC), wind energy could provide between 17-19% of global electricity by 2030 and 25-30% by 2050.

Until recently, the economical advantages of DFIG based wind energy conversion system (WECS) were undoubted, but the DFIG technology has been challenged in the past years by more stringent grid codes. The "fault ride-through" (FRT) requirement in particular led to modifications of the initial system and to an increased capital cost.

The dip in the grid voltage will result in an increase of the current in the stator windings of the DFIG. Because of the magnetic coupling between stator and rotor, this current will also flow in the rotor circuit and the power converters. So that it will cause over current in the rotor windings and over voltage in the dc bus of the power converters. When the situation after the fault is not serious enough, improved vector control strategy can provide adequate control of the DFIG during voltage dips with much smaller rotor currents and DC bus voltage [5]. However, its capability is limited by the relatively small rating of the power converters compared to the DFIG. When the grid fault is serious enough, the rotor current will increase too large and can not be controlled by the power converters. Without any protection, this will certainly lead to the destruction of the power converters. For protecting the converter, a common used solution is to connect the rotor circuit with a crowbar, which limits the high current in the rotor windings and provides a safe path for the high magnitude transient current [6-7].

2. WIND ENERGY CONVERSION SYSTEM (WECS)

The energy that can be extracted from the wind is directly proportional to the cube of the wind speed, so an understanding of the characteristics of the wind (velocity, direction, variation) is critical to all aspects of wind energy generation, from the identification of suitable sites to predictions of the economic viability of wind farm projects to the design of wind turbines themselves, all is dependent on characteristic of wind.

In a wind energy conversion system, the wind turbine converts the kinetic energy of the wind into the rotational energy; this rotational energy rotates the generator.

The wind nature either is constant speed or variable speed. The power fluctuation caused by the variable wind speed which can be reduced by using power electronic equipments such as converters with BESS, (Battery Energy Storage System).

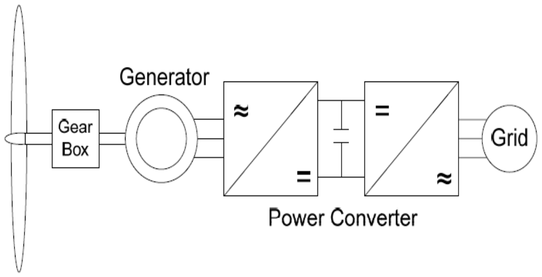

Figure 1: Wind Turbine with Induction Generator

Fig.1 shows the constant speed wind turbine which consists of Double fed induction generator. In this, the wind turbine is connected to the induction generator through the gear box and the pitch control technique is used to maintain the maximum speed

3. DOUBLE FED INDUCTION GENERATOR

The term 'doubly fed' refers to the fact that the voltage on the stator is applied from the grid and the voltage on the rotor is induced by the power converter. This system allows a variable-speed operation over a large, but restricted, range. The converter compensates the difference between the mechanical and electrical frequency by injecting a rotor current with a variable frequency. Both during normal operation and faults the behaviour of the generator is thus governed by the power converter and its controllers. The power converter consists of two converters, the rotor-side converter and grid-side converter, which are controlled independently of each other. The rotor-side converter controls the active and reactive power by controlling the rotor current components, while the line-side converter controls the DC-link voltage and ensures a converter operation at unity power factor. In both cases – sub synchronous and over synchronous – the stator feeds energy into the grid. The DFIG has several advantages. It has the ability to control reactive power and to decouple active and reactive power control by independently controlling the rotor excitation current. The DFIG has not necessarily to be magnetized from the power grid, it can be magnetized from the rotor circuit, too. It is also capable of generating reactive power that can be delivered to the stator by the grid-side converter. In the case of a weak grid, where the voltage may fluctuate, the DFIG may be ordered to produce or absorb an amount of reactive power to or from the grid, with the purpose of voltage control.

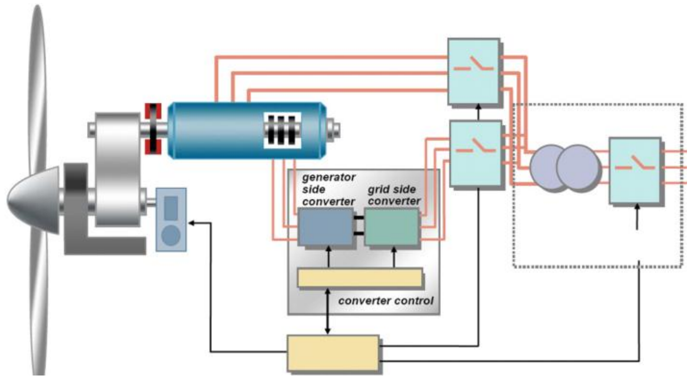

Figure 2: Simple layout of DFIG.

4. FAULT RIDE THROUGH CONTROL TECHNIQUE

Large scale of wind power has been installed in every where around the world. Both the wind farm installation capability and the WT capacity have increased rapidly. Although the time start to use of wind power in India is very late, the development is very fast. There were many constant speed wind turbines (CSWT) using stall control with squirrel cage induction generators (SCIG) installed in the wind farms in India. Newly installed WTs are dominated by variable-speed wind turbines (VSWT) using pitch control with DFIG. VSWT with direct-driven permanent-magnet synchronous generator (DDPSG) has been successfully studied and installed. Now the 6MW DDPSG WT used for the offshore wind farm has being developed. The wind power capacities installation in India has increased very rapidly. the wind power capacities installation in one province of India. Power system operation with increasing wind power penetration will become more and more difficult. More conventional power plants will be replaced by wind farms and accordingly the stability of the power system will be affected. So the new grid codes have proposed even strict requirement to the wind power. Not only the wind turbines should be kept connection in grid during the fault and fast recover power generation after fault clearance, but also the wind turbines or wind farm can provide the voltage support and generate capacitive reactive power . To meet this requirement, there are many researchers put their study on this subject. The studies can be mainly divided into three categories. The first one is mainly concern about the protection of the rotor side converter of DFIG WT during the fault. it has given a through discussion about the operation process of the rotor side crowbar of DFIG WT. it has provided a method to improve the vector control and limit the rotor current. it has proposed a new magnet excitation method to counteract the transient DC flux. The second one is mainly concern about how to make the wind turbine fast recover power generation after the fault clearance. it has discussed some methods to protect the VSWT with DFIG and DDPSG and their fast recover power generation capabilities. It has studied the double vector control method

5. MATLAB MODEL AND RESULTS

A model of wind energy conversion system has been implemented using Simulink/MATLAB.

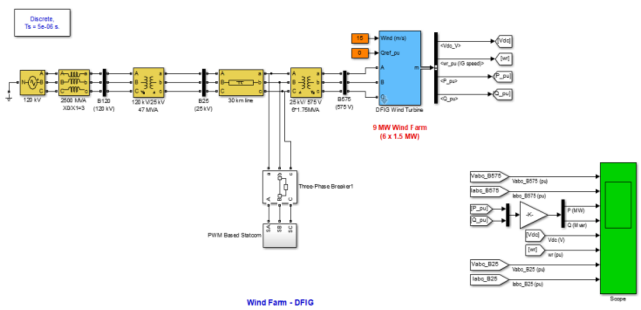

Figure.3: Simulink Model For WECS With FRT

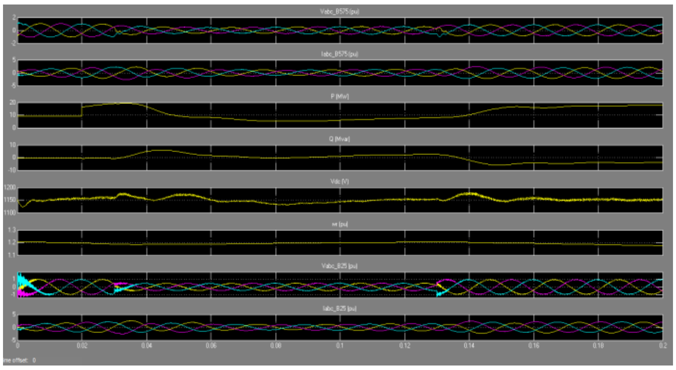

Figure.4: Result of Simulink model during fault by using FRT

V_{abc} at bus 575 is showing voltage near wind turbine. We can observe in the result, grid voltage dips at t=0.03 sec and remains till 0.13 sec. This dip in voltage should cause voltage dip at B575 but fault ride through capability of model using STATCOM kept voltage at bus 575 constant.

6. CONCLUSIONS:

This In this paper describes The full disturbance compensation method implies the estimation of the disturbing terms resulting from both the rotor and stator flux induced back e.m.f., and usage of these disturbances as feed-forward terms in the control structures. Based on the performed research and tested scenarios it can be said that this improved method of controlling the RSC provides good FRT capability. Riding through medium voltage drops without activating the crowbar and without coasting the RSC, while delivering reactive current support as requested by the grid codes, was achieved. As disadvantages for this method - the sustained oscillations in the stator flux, high rotor currents and large DC-Link fluctuations pose large mechanical and electrical stress on the WT.

7. References:

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