Review Paper on Wind Turbine using Dual fed Induction Generator Technology

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Abstract - The paper present Doubly Fed Induction Generator (DFIG) based wind turbine with variable speed variable-pitch control scheme which is the most popular wind power generator in the wind power industry. This machine can be operated either in grid connected or standalone mode. The paper offers discussion of RSC and GSC control scheme of wind turbine for cumulative modernization of wind turbine technology through literature survey of wind turbine configuration, mainly of double fed induction generator (DIFG).This paper gives proper understanding of control schemes, characteristics and limitation of DIFG.

Keywords: DFIG, GSC, RSC.

I. INTRODUCTION

The Doubly-fed Induction Generator (DFIG) is basically electric generator that fed ac currents into both the rotor and the stator windings. Most of the industry today are using three-phase wound-rotor induction generator as DFIG. Due to enormous advantages over the other types of generator, DFIG is recently most popular trend to use for extracting more wind energy.

The wind power generation uses either variable speed or fixed speed turbines which can be characterised into four major types. The main changes between these wind turbine types are the ways how the aerodynamic efficiency of the rotor would be imperfect for different wind speed conditions[2]. These four types are

1. Fixed Speed Wind Turbines (WT Type A)
2. Partial Variable Speed Wind Turbine with Variable Rotor Resistance (WT Type B)
3. Variable Speed Wind Turbine with Partial Scale Power Converter (WT Type C)
4. Variable Speed Wind Turbine with Full Scale Power Converter (WT Type D)

In this paper different method of wind turbines technology and different method of its power control technology mainly DFIG through control schemes are discussed. In the paper, the main control schemes discussed are RSC and GSC.

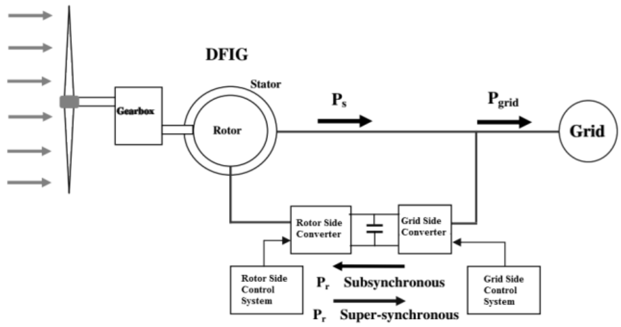

Figure 1: DFIG baised Wind Turbine Genrator System

II. CLASSIFICATION

Electric machines are either Single Fed with one multiphase winding set that actively participates in the energy conversion process or Double Fed with two active winding sets. An active winding set has at least two AC phases with independent electrical ports for the production of a rotating or moving magnetic field that actively participate in the energy conversion process. Since both winding sets of a doubly-fed electric machine actively participate in the energy conversion process, a doubly-fed electric machine operates to twice synchronous speed or twice the constant torque range with a given frequency of excitation [3,4].

Many confuse the singly-fed slip-energy recovery induction and the field-excited synchronous electric machines with two electrical ports as doubly-fed but only one port or winding set actively participates in the energy conversion process and as a result, these electric machines are not designed for operation to twice synchronous speed with a given frequency of excitation. A practical doubly-fed electric machine system must operate between sub-synchronous and super synchronous speed without control discontinuity [9].

Only practical with the evolution of control technology, there are now three varieties of doubly fed electric machine systems [3,4]:

1) The Doubly Fed Induction Machine (DFIM), which is the conventional wound-rotor doubly fed electric machine with an active winding set on the rotor and stator, respectively, and flux vector controlled rotor excitation through a multiphase slip-ring assembly.

2) The Brushless Doubly-Fed Induction Machine (BDFIM), which is the brushless doubly fed induction (or reluctance) electric machine with cascaded active winding sets of unlike pole-pairs on the stator assembly of which one is flux vector controlled and a flux focusing rotor assembly.

3) Synchro-Sym electric machine system, which is the only Brushless Doubly-Fed Synchronous Machine (BDFSM).

III. VARIABLE-SPEED WIND TURBINES

Variable-Speed wind turbines are designed to achieve maximum aerodynamic efficiency over a wide range of wind speeds. It has more complicated electrical system than that of a fixed-speed wind turbine. It is typically equipped with an induction or synchronous generator and connected to the grid through a power converter. The power converter controls the generator speed [5].

The advantages of variable-speed wind turbines are an increased energy capture, improved power quality and reduced mechanical stress on the wind turbine. The disadvantages are losses in power electronics, the use of more components and the increased cost of equipment because of the power electronics. The introduction of variable-speed wind-turbine types increases the number of applicable generator types and also introduces several degrees of freedom in the combination of generator type and power converter type.

IV. DFIG CONTROL OPTIONS

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. 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. The converter used in DFIG is back to back converter the back-to-back converter is highly relevant to wind turbines today [6,7,8].

Since the DFIG control is based on a fast IGBT converter, it offers several control options during steady state operation and grid faults. In steady state, it primarily controls the generator speed in accordance with a specified tracking characteristic to optimize the power output from the wind turbine. The reactive power channel can be used to control the grid voltage or follow instructions of the dispatcher like power factor or reactive power set points. During grid faults the reactive power control of both RSC and GSC can be used to support the grid through reactive current in-feed. The control structure of the DFIG-based wind turbines to be used in this study is based on a feed forward decoupled current control for RSC and GSC [9-15].

The RSC control structure involves of inner loop and outer loop in which the inner loop regulates the d-axis and q-axis rotor components, i.e. I_{dr} and I_{qr} , independently and the outer loop regulates the stator real power and reactive power autonomously. The stator voltage orientation (SVO) control principle for a DFIG is described in , where the q-axis of the rotating reference frame is aligned to the stator voltage i.e. V_{ds} = 0 and V_{qs} = V_s . the stator side flux can be controlled using PI controller. In this study, the q-axis flux is regulated to zero$(\psi_{qs} = 0)$ and $(\psi_{ds} = \psi_s)$ for the de-coupled control of real and reactive power [9-15].

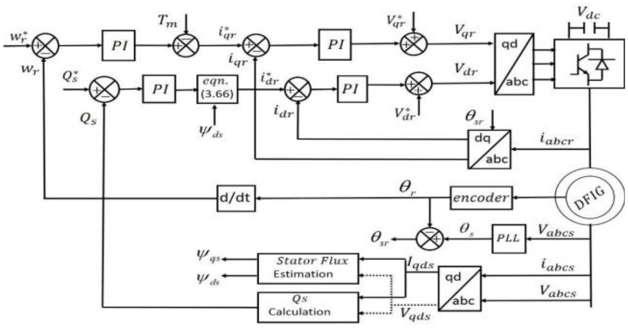

Figure 2 : Block diagram of RSC control system

The control mechanism of GSC which controls the voltage across the capacitor and reactive power exchange between the converter and grid is V_{dc} reached by controlling the current. Now, DC voltage dynamics in DC-link is given by [16,17,18]

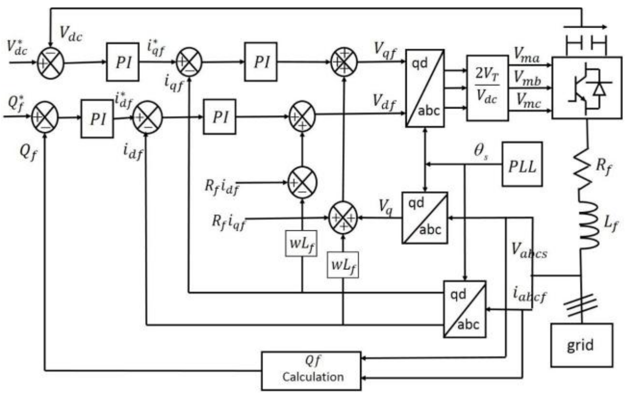

Figure 3: Block diagram of GSC control system

In the above mentioned controller the RSC and GSC controllers can designed separately and then combined together. This procedure is only valid when the controlled variables are independent of each other, i.e. they should be mutually decoupled[7,13,17].

V. CONCLUSION

The control strategies discussed above can be implemented effectively but needs appropriate tuning parameters to achieve decoupling. It often happens that if one current loop parameter varies, than the other loop output also varies and proper tuning is not achieved. In other words it is time consuming task to define proper tuning parameters. This problem occurs frequently in SFO control scheme. The PI controllers help in proper tracking of reference parameter which is generated according to the loading bus conditions. Also in fault/abnormal conditions or during wind speed variation, the output should be in stability limits.

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