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A Review on Wind Turbine and Wind Generator Used in WECS

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ABSTRACT

The applications of wind energy develop much rapidly than the other renewable resources such as solar, geothermal and so on in the 21st century. It becomes the third core energy resource following non-conventional fuels as oil and chemical. Electrical energy generated by wind power plants is the best ever developing and most promising renewable energy source. The wind is a clean, free and limitless energy source. Wind Energy Generation Systems (WECS) are confront with increasing demands for power quality and harmonic distortion control. With the advance in power electronics technology, the fast growth of variable speed WECS is now witness. However, the power quality still remains an important issue to be addressed thoroughly by researchers. This paper presents a comparative study on grid connected WECS having two different Wind Turbine Generator Systems (WTGS) using DFIG and PMSG.

Keywords : Wind Energy Conversion System, Wind Turbine Generator System

I. INTRODUCTION

At present, typically two types of WECS for large wind turbines exists [6-8]. The first one is a variable speed WECS using Doubly Fed Induction Generator (DFIG) that allows variable speed operation over a large, but still restricted, range. This type of WECS offer high controllability, smoother grid connection, maximum power extraction and reactive power compensation using back to back power converters of rating near to 25-30% of the generator capacity [7-9]. The second one is also a variable speed WECS using Permanent Magnet Synchronous Generator (PMSG). With PMSG the gear box can be eliminated by using large number of poles that allows higher efficiency. With large-scale exploration and integration of wind sources, variable speed wind turbine generators, PMSG [10-11] are emerging as the preferred technology. The complete modeling and simulation of a grid interfaced WECS based on DFIG, using dynamic vector approach is presented in [12-14]. WECS has been modeled and simulated for the following two WTGS configurations: (i) using DFIG and (ii) using PMSG with conventional or unconventional power electronic interface. The performance of both DFIG and PMSG based WECS have been compare in terms of power quality, active power, reactive power and speed control.

II. ASYNCHRONOUS(INDUCTION) GENERATOR

Asynchronous generator has two types:

i. Squirrel cage induction generator

This generator is used for constant-speed wind turbines.

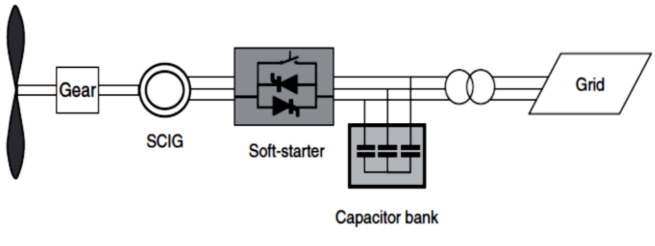

Fig. 1

The generator and the wind turbine rotor are attached through a gearbox. Wind turbines based on a SCIG are typically equipped with a soft-starter mechanism and an installation for reactive power compensation, as SCIGs consume reactive power. SCIGs have a steep torque speed characteristic and therefore fluctuations in wind power are transmitted directly to the grid.

ii. Wound rotor induction generator

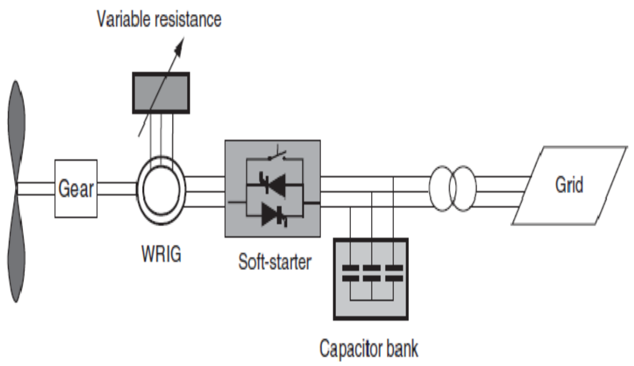

Fig. 2

Wound rotor induction has two subtypes:

a. Optislip induction generator

WRIG includes a variable external rotor resistance by means of which slip can be controlled. The converter is optically controlled, which means that no slip rings are necessary. The stator of the generator is connected directly to the grid. The advantages of this generator concept are a simple circuit topology, no need for slip rings and an improved operating speed range compared with the SCIG. To a certain extent, this concept can reduce the mechanical loads and power fluctuations caused gusts. However, it still requires a reactive power compensation system. The disadvantages include the speed range is typically limited to 0–10 %, poor control of active and reactive power is achieved and the slip power is dissipated in the variable resistance as losses.

b. Doubly 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 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.

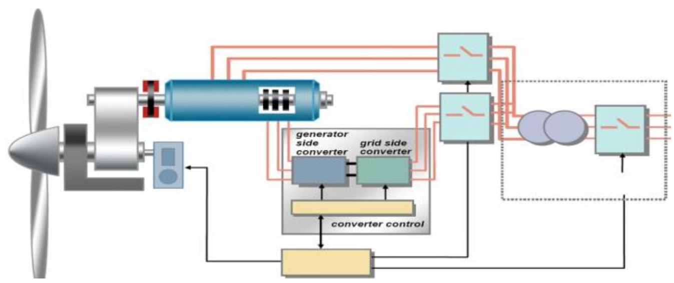

Fig. 3

1. Synchronous generator

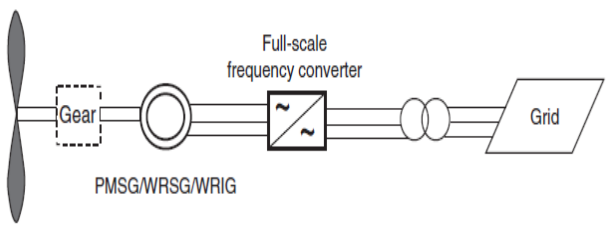

Fig. 4

Synchronous generator has two types:

i. Wound rotor generator

The stator windings of WRSGs are connected directly to the grid and hence the rotational speed is strictly fixed by the frequency of the supply grid. The rotor winding is excited with direct current using slip rings and brushes or with a brushless exciter with a rotating rectifier. Unlike the induction generator, the synchronous generator does not need any further reactive power compensation system. The rotor winding, through which direct current flows, generates the exciter field, which rotates with synchronous speed. The speed of the synchronous generator is determined by the frequency of the rotating field and by the number of pole pairs of the rotor.

ii. Permanent magnet generator

In the permanent magnet machine, the efficiency is higher than in the induction machine, as the excitation is provided without any energy supply. However, the materials used for producing permanent magnets are expensive, and they are difficult to work during manufacturing. Additionally, the use of PM excitation requires the use of a full scale power converter in order to adjust the voltage and frequency of generation to the voltage and the frequency of transmission, respectively. This is an added expense. However, the benefit is that power can be generated at any speed so as to fit the current conditions.

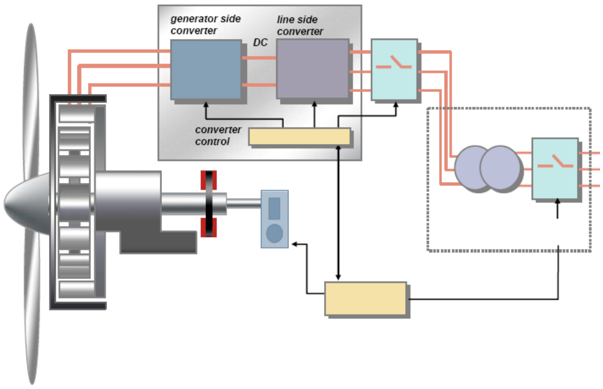

Fig. 5

III. RESULT AND CONCLUSION

This paper provides a brief and comprehensive survey of the generator and power electronic concepts used by the modern wind turbine industry. A short introduction, presenting the basic wind turbine topologies and control strategies, was followed by the state of the art of wind turbines, from an electrical point of view. Old and new potentially promising concepts of generators and power electronics based on technical aspects and market trends were presented. It is obvious that the introduction of variable-speed options in wind turbines increases the number of applicable generator types and further introduces several degrees of freedom in the combination of generator type and power converter type. A very significant trend for wind turbines is that large wind farms will have to behave as integral parts of the electrical power system and develop power plant characteristics. Power electronic devices are promising technical solutions to provide wind power installations with power system control capabilities and to improve their effect on power system stability.

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