A Review: Control Strategy of Doubly Fed Induction Generator

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Abstract -The wind turbine technology is now a developed technology. Modern wind technology is important for generation of power grid integration, stability and power quality issues in the arena of reliable power production to user end or utility. The paper described cumulative modernization of wind turbine technology. According to literature survey DFIG is very beneficial for industrial purpose so, its very important to study the how control DFIG. This paper gives information about different control strategies of doubly fed induction generator and proper concept of DFIG and control their characteristics and limitations.

Key Words: Doubly fed induction generator, Fixed speed wind turbine, Variable speed wind turbine, different Control technique.

1 Introduction

Day by day pollution has become a big problem in people daily life. As we know that day by day to increase the use of power and as compare to generation is less so, it is major problem in people daily life along with non renewable generating sources also decreases therefore for increase the generation we have to be use of renewable source such as wind energy, solar energy, etc. wind power has the fastest growing speed in the power generation. wind power is use in many countries by way of government-level policy. We will study by 2020 20% power generate by wind there supplying by large-scale offshore wind farms. Now planning for large the capacity of the large-scale offshore wind farms to more than 30 GW power by 2015 in Europe. Other countries such as also have promising large wind power resources and similar plans for wind farm installation. In the past decay wind power generation has faced a very fast development. Therefore in this paper the focus is put on the wind power generation as it is said to encounter large integration obstacles and possible solutions in the near future. The first nuclear reactor of bar seb ¨ack was shut down 30th of November 1999. Nuclear power production shall be replaced by improving the efficiency of electricity use, conversion to renewable forms of energy and other environmentally acceptable electricity production technologies. According to wind power can contribute to fulfilling several of the national environmental quality objectives decided by Parliament in 1991. Continued expansion of wind power is therefore of strategic importance. In Sweden, by the end of 2004, there was 442 MW of installed wind power, corresponding to1% of the total installed electric power in the Swedish grid. These wind turbines produced 0.8 TWh of electrical energy in 2004, corresponding to approximately 0.5% of the total generated electrical energy .Wind turbines (WTs) can either operate at fixed speed or variable speed. For a fixed speed wind turbine the generator is directly connected to the electrical grid. For a variable speed wind turbine the generator is controlled by power electronic equipment. There are several reasons for using variable-speed operation of wind turbines; among those are possibilities to reduce stresses of the mechanical structure, acoustic noise reduction and the possibility to control active and reactive power. Most of the major wind turbine manufacture developing new larger wind turbines in the 3-to-5-MW range. These large wind turbines are all based on variable-speed operation with pitch control using a direct driven synchronous generator (without gearbox) or a doubly-fed induction generator (DFIG). Fixed-speed induction generators with stall control are regarded as unfeasible for the large wind turbines. Today, doubly-fed induction generators are commonly used by the wind turbine industry (year 2005) for larger wind turbines. The major advantage of the doubly-fed induction generator, which has made it popular, is that the power electronic equipment only has to handle a fraction (20–30%) of the total system power. This means that the losses in the power electronic equipment can be reduced in comparison to power electronic equipment that has to handle the total system power as for a direct-driven synchronous generator, apart from the cost saving of using a smaller converter.

1.1 Fixed-Speed Wind Turbine

For the fixed-speed wind turbine the induction generator is directly connected to the electrical grid according to Fig.1 The rotor speed of the fixed-speed wind turbine system has often two fixed-speed. This is accomplished by using two generator.

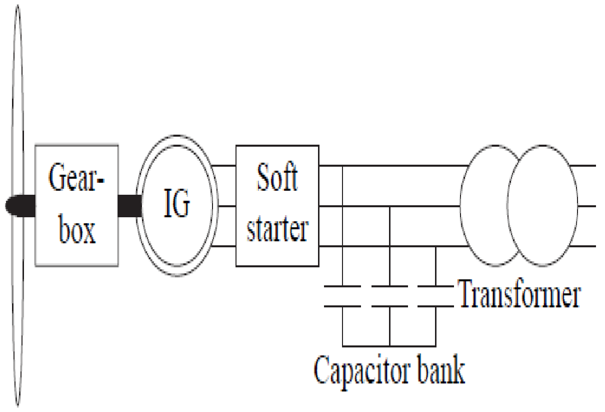

Fig. 1: fixed-speed wind turbine with induction generator

The fixed-speed with different ratings and pole pairs or it can be a generator with two windings having different ratings and pole pairs. This leads to increased aerodynamic capture as well as reduced magnetizing losses at low wind speeds.

1.2 Variable-Speed Wind Turbine

The system presented in Fig.2 consists of a wind turbine equipped with a converter connected to the stator of the generator or a synchronous generator. The gearbox is designed so that maximum rotor speed corresponds to rated speed of the generator. Synchronous generators or permanent-magnet synchronous generators can be designed with multiple poles which implies that there is no need for a gearbox, see fig. Since this "full-power" converter/generator system is commonly used for other applications, one advantage with this system is its well-developed and robust control. A synchronous generator with multiple poles as a wind turbine generator is successfully manufactured by Enercon generator. The generator could either be a cage-bar induction motor.

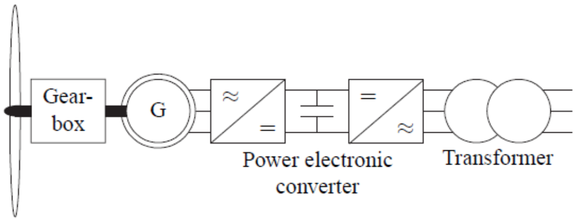

Fig.2: Variable-Speed Wind Turbine with Induction Generator

1.3 Doubly-Fed Induction Generator Systems for Wind Turbines

For variable-speed systems with limited variable-speed range, e.g. ±30% of synchronous speed, the DFIG can be an interesting solution. As mentioned earlier reason for this is that power electronic converter only has to handle a fraction of the total power. This means that the losses in the power electronic converter can be reduced compared to a system where the converter has to handle the total power. In addition, the cost of the converter becomes lower. The stator circuit of the DFIG is connected to the grid while the rotor circuit is connected to a converter via slip rings. The DFIG and also the power factor at the stator terminals, while the main objective for the grid-side converter is to keep the dc-link voltage constant. DFIG can operate both in motor and generator operation with a rotor-speed range of $\Delta\omega$max. A typical application, as mentioned earlier for DFIG is wind turbines, since they operate in a limited speed range of approximately ±30%. Other applications besides wind turbines for the DFIG systems are, for example, flywheel energy storage system stand-alone diesel systems pumped storage Power plants or rotating converters feeling a railway grid from a constant frequency.

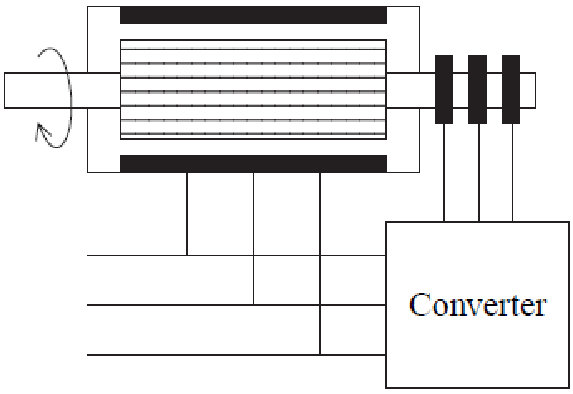

Fig. 3: Principle of DFIG

1.4 Control Strategies for a Wind Turbine-Generator System

The control schemes for a wind turbine-generator system include the pitch angle control, maximum power point tracking control, and the DFIG control. The control techniques and advanced control techniques for wind turbine-generator systems are reviewed in this section.

1.4.1 Pitch angle control

The pitch angle control is a mechanical method of controlling the blade angle of the wind turbine when the captured wind power exceeds its rated value or wind speed exceeds its rated value. In this way, pitch angle control is enabled to limit the maximum output power to be equal to the rated power, and thus protect the generator. When the wind speed experiences gusts. The pitch angle controller is only activated at high wind speeds. There are numerous pitch angle regulation techniques described in the literatures. The conventional pitch angle control usually uses PI controllers. However, several advanced pitch control strategies were proposed. A new approach for the pitch angle control which worked well for unstable and noisy circumstance was presented in. Besides a fuzzy logic pitch angle controller was developed in which did not need much knowledge about the system. Furthermore a pitch angle controller using a generalized predictive control was presented in, whose strategy was based on the average wind speed and the standard deviation of the wind speed. Another pitch control scheme was proposed in which a self-tuning regulator adaptive controller that incorporated a hybrid controller of a linear quadratic Gaussian neuro-controller and a linear parameter estimator was developed for the pitch angle control. In the authors only applied a fuzzy logic pitch angle controller in a wind turbine-generator system to achieve the maximum power point tracking control and power control.

1.4.2Maximum power point tracking control

In order to achieve the maximum power point tracking (MPPT) control, some control schemes have been presented. The maximum power point tracking control can be mainly divided into two types. They are the conventional control schemes and intelligent control schemes.

1.4.2.1 Conventional control schemes

The conventional control schemes can also be divided into current mode control and speed mode control which depends on the setting of reference values. The reference values are the active power and electromagnetic torque for current mode control and the rotational speed for the speed mode control. In the author compared these two control strategies for dynamic transient analysis and concluded that the current mode control has slow response with simple construction while the speed mode control has fast response with complex construction. The discussions and limitations of these two control schemes were presented in. In fact the wind speeds in above conventional control schemes need to be exactly measured. However the anemometer cannot precisely measure the wind speed because of the flow distortion, complex terrain and tower shadow influence. Hence some studies on maximum wind energy tracking without wind velocity measurement had been developed.

1.4.2.2Intelligent Control

The intelligent control strategies usually apply the hill-climbing control and the fuzzy logic control to the maximum power point tracking control. The traditional hill climbing control uses a fixed-step speed disturbance optimal control method to determine the speed, perturbation size and direction according to the changes in the power before and after sampling. However this control method is usually slow in speed because the step disturbance is fixed. Therefore some improved hill-climbing control methods were proposed. For example, a method of using variable-step wind energy perturbation method to control the captured wind power was analyzed in. Another advanced hill-climbing searching method with an on-line training process which can search for the maximum wind turbine power at variable wind speeds, even without the need for knowledge of wind turbine characteristics, wind speed and turbine rotor speed, was developed in Fuzzy logic control based MPPT strategies have the advantages of having robust speed control against wind gusts and turbine oscillatory torque, having super aerodynamic and steady performances, and being independent of the turbine parameter sand air density.

1.5 DFIG control

Control of the DFIGs is more complicated than the control of a squirrel-cage induction generator because the DFIGs can operate at sub-synchronous speed and super-synchronous speed by regulating the rotor terminal voltages. Through the years many researchers have presented various types of DFIG control strategies such as field oriented control, direct torque/power control, predictive control, sensor less control and nonlinear control.

1.5.1 Field Oriented Control

Field oriented control (FOC) or vector control is commonly used in doubly-fed induction generator controls due to its ability of controlling the motor speed more efficiently and the low economic cost to build an FOC system. Field oriented control also provides the ability of separately controlling the active and reactive power of the generator. Currently there are mainly two types of field oriented control in DFIGs, which are stator voltage oriented control and stator flux oriented control, respectively. The stator flux oriented control is widely used in the DFIG control designs in which the q-axis current component is used for active power control and the d-axis component is used for reactive power control. While for the stator voltage oriented control, the situation is on the contrary the d-axis component is used for active power control and the q-axis current component is used for reactive power control. In the author compared real and reactive power control for a DFIG-based wind turbine system using stator voltage and stator flux oriented control respectively and the simulation results illustrated same performances.

1.5.2 Direct Torque/Power Control

Recently a new technique for directly control of the induction motors‟ torque or power was developed which included direct torque control (DTC) and direct power control (DPC). Direct torque control scheme was first developed and presented by I. Takahashi and T. Nogouchi. Based on the principles of DTC for electrical machines direct power control for a three-phase PWM converter was introduced in. Direct torque control techniques do not require current regulators co-ordinate transformations specific modulations and current control loops. Thus direct torque control has the ability of directly controlling the rotor flux linkage magnitude and generator torque through properly selecting the inverter switching states. To show the advantages of DTC the comparison between the field oriented control and direct torque control was made indirect torque control using space vector modulation technology was presented.

In the authors applied basic direct torque control to a doubly-fed induction generator. Direct torque control which was achieved without PI controller and only required the knowledge of grid voltages, rotor currents, and rotor position as was proposed in. Z. Liu, in proposed an ovel direct torque control scheme which was developed based on the control of the rotor power factor. Direct power control has the mere requiring fewer sensors having low computational complexity, fast transient response and low machine model dependency compared with direct torque control. In the comparison between field oriented control and direct power control for a PWM rectifier was presented and the simulation results showed that the virtual-flux-based direct power control was superior to the voltage-based direct power control and field oriented control. Direct power control has been applied in DFIG-based wind turbine-generator systems in recent years. In and the authors used direct power control in a DFIG-based wind turbine system under unbalanced grid voltage conditions.

1.6 Conclusion

Above discussed control system can be implemented successfully but needs proper tuning parameters to achieve decoupling. It often happens that if one current loop parameter varies, 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. The nonlinear relations of active and reactive power flow are simplified and under certain assumptions and constraints they are related to the operating voltage, current and phase angles. In all above discussed control schemes, current loop and voltage loop exist and the effect of phase angle in considered in stationary to synchronous frame and vice-versa. The parameters to be controlled in stationary frame are controlled in synchronous frame in the form of steady state or d. c. values of *dq* axis. At last the control techniques are effective for better performance of DFIG WT systems and the applied control system needs to be stabilizing for the given constraints.

1.7 References

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