IMPLEMENTATION OF DOUBLY-FED WIND TURBINE ALONG WITH PID CONTROLLER TO MAINTAIN THE DESIRED OUTPUT LEVELS AND CONTROL THE PITCH ACCORDING TO WIND DIRECTION

AJAY SHUKLA, ANIL GUPTA

M.Tech. Scholar, Department of Electrical and Electronics Engineering, LNCT, Bhopal, India
Assistant Professor, Department of Electrical and Electronics Engineering, LNCT, Bhopal, India

ABSTRACT

In order to increase energy demand, alternative source of energy generation is required. A many hybrid system involve wind system due to availability and easy access of wind resource. The wind generated power fluctuating due to time varying nature and causing stability problems. When Wind turbine system is connected to the power grid to generate power always fluctuating due to environmental conditions. This paper is to modify and simulation for a wind farm with a high voltage transmission network. Here model is designed to control pitch angle by using PID controller and to maintain output level by stabilizing rotor speed. Analytical model of wind turbine has been presented and this was followed by the modelling of the wind farm under Sim Power of simulink. The stimulated turbine system uses a Doubly fed Induction Generator (DFIG) having a capacity of 9 MW wind farm comprising of six 1.5 MW wind turbines linked with 25 kV distribution system transfers power to a 120 kV grid for a 30 km, 25 kV feeder. Initially in this model the wind speed is maintained constant at 15 m/s. PID Controller is introduced to regulate speed of rotor by adjusting pitch which controls speed changes. Result shows due to controlling of pitch angle output level is improved and good quality factor is achieved. We have applied fuzzy controller to establish maximum power delivery to the grid at trip. This design having full control on the electrical torque, speed and also makeup a reactive power compensation and operation under grid disturbances which improve desired output levels.

Key words--- Modelling simulation, DFIG, PID Controller, Pitch angle, output, Fuzzy logic Control

1. INTRODUCTION

Due to heavy requirement of electricity, renewable energy has been widely developed. Wind power technology is one of the most popular renewable energy that is clean, easy maintenance, low cost and plentiful on the earth. Man well and Rogers (2002), [1], defines conversion of kinetic energy from the wind into both mechanical energy and electrical power. In the early days, large farms used wind power generated by windmills to do farm works. Recently, advanced technology enables wind turbines to generated large electrical power to full fill the energy demand. Wind turbine technique has been greatly developed in the past few decades.

Doubly - fed electric machines are basically electric machines that are fed ac currents into both the stator and the rotor windings. Mostly doubly fed electric machines in industry are three phase wound - rotor induction machine, and are one of the most common types of generator used to produce electricity in wind turbines.

The primary advantage of doubly - fed induction generators when used in wind turbines is that they allow the amplitude and frequency of their output voltages to be maintained at a constant value, doesn’t effects the speed of the wind blowing on the wind turbine rotor. By the, doubly fed induction generators can be directly connected to the ac power network and remain synchronized at all times with the ac power network and includes the ability to control the power factor.[2]

The problems encountered in the electrical network comprising wind energy systems are due to the continuous variations in the wind regime. These variations may inflect undesirable fluctuation in the network and thus has limited the capacity of the wind energy systems which can be integrated with the network to a modest penetration factor. Various techniques have been proposed to cope with the variations in the wind speed to ensure high performance and steady output for the wind energy systems and hence contribute to allow for higher penetration factor.

The effect of the variation in the wind speed may result in:
1- Change in the output voltage
2- Change in the output frequency
3- Change in the output power
4- Shift in the operating point

The maintain change in the output voltage and frequency is is discussed in this paper by adopting the system which employs a doubly fed induction generator connected to the network. The voltage and frequency are govern by the main network, the variation in the output power is
we form a fuzzy rules, fuzzy rules are based on definite decision i.e., in the form of IF-THEN. Finally when all the operations of control is completed at the last stage the fuzzy variables are again converted into real variables which is as known defuzzification.[5]

In order to extract maximum power from available wind have to take fuzzy logic control of generator side converter and thus control of generator speed was used. The advantages in using fuzzy logic controller is pointed out in better response to frequently changes in wind speed [6].

2. PREVIOUS WORK

Several techniques have been used in the past years on model of wind systems for power generation. Mostly existing models are analytical while others are computer based. Hansen & al. [7], provided a comprehensive report on the modelling of wind turbine at both system and component level using the DigsILENT software. Their work dealt with the description of DigsILENT built-in models of electrical components used for wind turbine system comprising: an induction generator, a power converter and other models developed by user in the dynamic simulation language (DSL) of DigsILENT. Also, models of non-electrical components of wind turbine system such as wind speed model, aerodynamic model and others, were equally made available.

The three phase injected current into the grid from STATCOM will cancel out the distortion caused by the nonlinear load and wind generator. The IGBT based three-phase inverter is connected to grid through the transformer. The generation of switching signals from reference current is simulated within hysteresis band of 0.08. The choice of narrow hysteresis band switching in system improves the current quality and control signal of switching frequency within its operating band. [8]

In addition, Bolik (2004), developed a computer model of wind turbine that has been widely used by power-system operators to study load flow, steady state, voltage stability, dynamic and transient behaviour of power system. This system was also simulated with DigsILENT. DigsILENT has the capability to simulate load flow, RMS fluctuations and transient events. It provides models on different levels and can also be used to simulate load flow, RMS fluctuation and transient events in the same environment.

Besides and Fingersh & al. (2006), [9] developed under The National Renewable Energy Laboratory (NREL), an agency of US, a wind turbine model intended to provide reliable cost projections for wind-generated electricity based on different scales (sizes) of turbines. The model was mainly analytical. Petru (2001), has also developed a

addressed in a companion paper by using a storage battery to smooth the changes in the output power[3].

Initially for the improvement of power quality or reliability of the system FACTS devices like static synchronous compensator (STATCOM), static synchronous series compensator (SSSC), interline power flow controller (IPFC) and unified power flow controller (UPFC) etc. These FACTS devices are created for the transmission system. But now a days more attention is on the distribution system for the improvement of power quality. In these devices variations are introduced and known as custom power devices. The custom power devices which are used in distribution system for power quality improvement are distribution static synchronous compensator (DSTATCOM), dynamic voltage restorer (DVR), active filter (AF), unified power quality conditioner (UPQC) etc.

For renewable source of energy Wind energy are focused, and has become gradually more widespread. Wind turbines use wind-energy capturing systems. Pitch control, which is normally required to attain a stable output power when the wind speed is above the evaluated wind speed, is accomplished by regulating the pitch angle of the wind turbine blades to limit the output power and protects wind turbine gearbox and generator. Therefore pitch control designed for variable-speed turbines are increasingly critical which is modified in this paper by fuzzy logic controller.

The proportional-integral-derivative (PID) controller is the common closed-loop control system which improves overall response of system is using to design the pitch control system. In addition to typical PID control systems, studies have suggested different methods for controlling the pitch angle. Modern studies have adopted to determine the stability region of PID control systems. In stable synthesis of a PI-based pitch controller was suggested. A graphical methodology was used to define the stability region and set the parameters of the controller to achieve an arbitrary-order time delay system. An alternate way to regulate the pitch angle in wind turbine generators is setting various operating points for the control system [4].

Fuzzy logic Controller is used with trip to optimize itself according to angle of wind flow. Fuzzy Logic is created by logical functions. The conception of Fuzzy logic is derived from set theory. There are several controllers which provide effectual control for linear systems. In case of nonlinear systems a Fuzzy Logic Controllers are used. Fuzzification, rule formation, and defuzzification are the steps present in fuzzy logic system to perform operation. The input to the fuzzy controller is in the form of real variables. In the process of fuzzification the real variables are converted into fuzzy variable and each fuzzy variable are represented by membership function. In second step
similar analytical model of wind turbine as a project work and this was well elaborated on other aspects of wind system such as the aerodynamic modelling, the wind data modeling, the mechanical aspect

Moreover, Sulla (2009), [10] modeled and simulated a doubly fed Induction Generator and the fixe speed Induction generator with MATLAB Sim power system toolbox. The system was made of a graphical model built under Simulink with already existing models for transmission line, loads, wind turbine and others. Several cases of faults have been tested and analysed in order to show the robustness of the system.

Bharanikumar (2010), presents a maximum power point control for variable speed turbine driven permanent magnet generator [11]. In summary, his paper discusses the variable-speed wind energy conversion system using a permanent magnet generator and proposes the optimal control strategy of permanent magnet generator that helps to maximize the power generated.

Furthermore R. Melicio (2009), [12], developed a model of WTGS using a permanent magnet synchronous generator. The work aimed at improving the transient stability of the system by acting on the pitch angle. A new control strategy was proposed and simulated; simulation results show an improvement of system performances and robustness. In addition an analysis was carried out on the Total Harmonic Distortion (THD), which is a measure of system quality. Results show that the total THD was much lower than 5% which is the limit imposed by IEEE-519 standard. In summary, the above review of literature demonstrate that wind turbine modeling mostly goes with the use of doubly fed or squirrel cage induction generator and can be modeled and simulated under various conditions by two reputed software namely, DigsILENT and MATLAB. It was also found that, models of computation and validation of wind data, including Stochastic, Deterministic, Weibull and Exponential models were made available under MATLAB software.

3. METHODOLOGY

Simulation Methods of the Designed and Implemented model. On the basis of the frequency range to be represents, three simulation methods are presently available in Sim Power Systems to model VSC based energy conversion systems connected on power grids. The phasor model (continuous): This model is better adapted to simulate the low frequency electromechanical oscillations over long periods of time (tens of seconds to minutes). In the phasor simulation method, the sinusoidal voltages and currents are substituted by phasor quantities (complex numbers) at the system minimal frequency (50 Hz or 60 Hz). This is the technique which is also used in transient stability softwares. A 9 MW wind farm comprising of six 1.5 MW wind turbines linked to a 25 kV distribution system transfers power to a 120 kV grid through a 30 km, 25 kV feeder. However to enhance its power generation and quality of the generated power PID controller has been implemented over the wind speed block so as to control and regulate the wind speed according to the desired output power, also PID controller works only on the proportional constant and the integral value to attain the maximum output from the wind. Proportional constant can be further termed as the gain constant of the PID Controller. Wind Turbines do not operate at the speed above 55 miles per hour; this can be overcome by the use of PID Controller. As the PID Controller controls the wind speed for the designed model it becomes equally important to regulate the trip of the wind turbine as the amplified wind speed output may damage or block the wind turbine. To control the trip or the blade direction of the wind turbines Fuzzy Logic or Vector control method can be used, however in this model Fuzzy Logic is used as it is more responsive accurate and less complex than the vector control box. To control the pitch of the blades fuzzy logic generate a pulse to maneuver the blade direction or its pitch, so that the blades always remain in parallel to the wind and keep rotating to generate the maximum output. Wind turbines via a doubly-fed induction generator (DFIG) comprise of a wound rotor induction generator and an AC/DC/AC IGBT-based PWM converter. The stator winding is connected straight to the 60 Hz grid whereas the rotor is fed at variable frequency through the AC/DC/AC converter. 120 KV generator is required to synchronize the output power generated by the wind turbine. The DFIG technology permits extracting maximum energy from the wind form low wind speeds by optimizing the turbine speed, while decreasing mechanical stresses on the turbine during gusts of wind. Initially in proposed model the wind speed is maintained constant at 15 m/s. The control system uses a torque controller in order to maintain the speed at 1.2pu. The reactive power generated by the wind turbine is regulated at 0 Mvar at a wind speed of 15 m/s, the turbine output power is 1 pu of its rated power, the pitch angle is 8.7 degree and the generator speed is 1.2 pu. A proportional-integral-derivative controller (PID controller) is a control loop feedback mechanism (controller) widely used in industrial control systems. The PID controller computes an error value as the difference between a measured process variable and a desired set point.

Fuzzy Logic A fuzzy control system is a control system based on fuzzy logic—a mathematical system that analyses analog input values in terms of logical variables that take on continuous values between 0 and 1, in contrast to classical or digital logic, which operates on discrete values of either 1 or 0 (true or false, respectively).
4. RESULTS

Figure 1: Detailed Proposed MATLAB Model

Output Responses

Figure 2: Output Response of Wind Turbine
5. CONCLUSIONS

On implementing PID controller with wind turbine have controlled the desired output level and power quality also improved. This system is previously proposed for capacity of 9 MW but after introducing PID controller, its transient and steady state response is improved so its output power reached upto 30 MW.

In this paper, I also controlled the pitch angle of wind turbine by introducing fuzzy logic controller with trip to control its angle of blades according to wind flow.

REFERENCE


[2] Principles of Doubly-Fed Induction Generators (DFIG); Courseware Sample 86376-F0 - 01/2015


Conference on Power Systems Transients (IPST2009) in Kyoto, Japan June 3-6, 2009