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A comparative analysis of Reactive Power Management Strategies Under Distributed Generation

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1. INTRODUCTION:

Emerging environmental concerns and limited availability of fossil fuels have put more emphasis on renewable energy based distributed generation. Among the various renewable energy sources, wind energy is one of the most promising and fast developing energy source. The integration of Wind power into the existing power system has been increasing very rapidly worldwide. The power generation utilizing wind energy has numerous advantages such as clean generation, free and abundance availability etc. But due to the intermittent nature and limited predictability of wind, energy generation from wind presents some differences from more traditional or conventional energy resources. With the increased level of penetration, the power system operation and control has become challengeable due to major concern of power system security, stability and reliability as the output wind power is variable. Moreover, the problem becomes more prominent when the wind power has to be integrated into weak grid. In order to regularize wind energy generation and integration with the grid, different countries are continuously developing new grid codes and standards that adapt the wind energy generation to the specific characteristics of their electric grids Grid codes are set up to specify the relevant requirement in order to integrate wind farm to the Grid. These requirements are technical regulation regarding the connection of large wind farm to the transmission and distribution system, including, system voltage and frequency variation limits, active power control and frequency control, as well as reactive power and voltage regulation capabilities, fault ride through capability. Fault ride-through capability refers to the wind generators capabilities to remain connected to system Grid at voltage levels below nominal value in the event of occurrence of fault in the system. Also wind turbine has to deliver reactive power to support grid voltage in the fault conditions. Technological advances in the field of wind energy generation have been undergoing by putting more emphasis on the following points-:

1. More advanced design of wind turbine.

2. More accurate prediction of wind energy.

3. Systematic approach to the operation and planning in the future electrical energy system.

2. LITERATURE SURVEY:

Brief review of the literature concerned with wind power generation technology. H, Li, Z. Chain in presents the overview and penetration level of different wind generator and it is shown that variable concepts with power electronics will continue to dominate large scale wind farms. In [2] decoupled control of active and reactive powers using the vector control is presented. In [3] a control strategy has been developed for the reactive power regulation of wind farms made up with DFIG to control the voltage at PCC. In the steady-state operating chart of the DFIG has been derived by considering the current and thermal limits of the rotor circuit. This paper also described the techniques used to control power factor of DFIM considering only RSC for Reactive power supports. In a PI-based control strategy to manage the net reactive power interchanged between the grid and wind farms. Net reactive power set-points used for reactive power control of wind farm are derived by an Optimal Power Flow (OPF) algorithm. Ref [6] Describes different methods of voltage control contributed by the DFIG, by considering various network parameters and operating conditions (e.g., overloading, power prioritization, etc.).Different combinations of reactive power control using both rotor side converter (RSC) and grid side converters (GSC) are investigated for voltage-control purposes. However, reactive power regulation using RSC is much more effective. Ref [7] presents the passive method (L, C) and active method (wind generator, FACTS) is proposed. P-Q curve is also derived for different power factor. In reactive power capability of a unified DFIG having three converters is investigated considering RSC, GSC and SGSC. Utilization of extra converter facilitates LVRT and additional reactive power support. In full reactive capability of a DFIG based wind park reduced the system losses. The additional reactive support was also found to improve voltage clearance by damping oscillations and preventing overshoots just after being subjected to a disturbance. In a VSC (variable structure control) with direct power controlsolution for DFIG drives has been proposed to control the active and reactive powers directly without frame transformation that provide robust control independent of machine parameters. By combining the reactive power compensation ability of both DFIG and reactive power compensation device (RPCD) an optimal control strategy for reactive power in wind farms consisting of variable speed constant frequency DFIG based wind turbine is proposed in Sensitivity Analysis and improved genetic algorithm is used to optimize the control strategy. The proposed control strategy achieve the target of minimum power loss and OPF. In Ref [12] the components and the basic concepts of fixed speed wind turbine (FSWT) and variable speed wind turbine are explained. Also the steady state and dynamic modeling and control of DFIG based wind turbine have been described. In a novel control scheme based on rotor flux vector magnitude and position is proposed that has the ability to contribute voltage support and recovery following network fault and improves the overall damping and contribute to the short term frequency regulation. In a new direct power control strategy (DPC) for a DFIG based wind energy conversion system has been proposed that control the direct active and reactive power by selecting appropriate voltage vector on rotor side that utilize stator flux estimation. The proposed strategy shows the effectiveness and robustness under the changing operating conditions and machine parameters. In reactive power capability has been studied by taking into account the stator current, rotor current and steady state stability limit of the generator. However, Reactive power capability limit of GSC is not considered here. Presents the dynamic modeling and analysis of DFIG based wind farm connected to a transmission system. Different converter control and protection strategies have been analyzed during grid fault condition. Ref [17] Compare the PI controller and Neural Network (NN) controller under normal and fault conditions. The results shows that the NN based controller provides better dynamic characteristics. In coordinated control of DFIG based wind turbine and STATMOM, both placed at PCC, has been demonstrated on Real time Digital Simulator under short circuit grid fault conditions. The proposed scheme improves the transient voltage stability and enhances Low voltage Ride through (LVRT) capability of wind turbine generator during grid fault. In [19] the reactive power capability of DFIG based wind farm connected with distribution feeder is optimized by Particle Swarm Optimization (PSO) to support systemvoltage. Ref [20] proposed a reactive power controller design that enables the control of active and reactive power independently using both RSC and GSC. The proposed scheme used the linear control technique resulting in the power loss reduction by sharing the reactive power between the two converters. Ref [21] proposed a joint optimization algorithm by considering reactive power capability of wind farm and distribution network reconfiguration. In Both Fixed Speed Wind Turbine (FSWT) and Variable speed Wind Turbine (VSWT) DFIG based wind park topology is used and a new Direct Power Control (DPC) strategy based on Discrete Space Vector Modulation (DSVM) technique is applied for DFIG based turbine. In the presented scheme, VSWT DFIG fulfills the necessary requirement of FSWT during the network disturbance which is the cost effective solution to improve the stability and meet the grid code requirement. In a coordinated reactive power management strategy between DFIG based wind turbine and FACTS (SVC) has been introduced. Genetic algorithm is used for proper utilization of reactive power of coordinated system. Both RSC and GSC are considered for the Reactive power capability of wind turbine. Ref [24] Derived the complete P-Q curve of DFIG based wind turbine by considering all the limiting factors such as generator current, converter current, stator and rotor voltages, non-linear relationship between junction temperature and magnetic flux saturation.

3. PROBLEM DEFINITION :

Voltage stability problem is the main concern with grid integrated wind farm. The variations of the generated active power, short circuit in the system, system loading, tripping of transmission line or transformer tap changing results in the variations of the voltage at PCC . The voltage at Point of common coupling (PCC) should be maintained within system operator's regulatory limits. The Voltage regulation in power systems is directly related to the control of reactive power. To mitigate the voltage stability problem, the steady state and dynamic reactive power compensation resources within wind farm are required to be equipped and planed to regulate adequate amount of reactive power in the network. Thus, the reactive power management becomes an integral issue in the grid-integrating wind farms. The modern variable speed wind turbine generators equipped with power electronics converters has the capability to generate/absorb the reactive power both in normal andfault conditions by adopting appropriate control strategy. Both Doubly Fed Induction Generator (DFIG) and full scale convertor with permanent magnet synchronous generator (PMSG) based wind farm can provide smooth reactive power regulation to provide voltage support to the network as well as to fulfill the grid code requirement. Additional reactive power sources may be necessary if the supply of reactive power from the WT to the grid leads to high voltage drops and thus reactive losses in the lines . Also, lack of fault-ride through (FRT) capability by WT, upon the activation of crowbar protection, may necessitate using separate reactive power sources like SVC, STATCOM installed close to the grid connection point.

4. RESEARCH OBJECTIVE:

Following are the research objectives those are to be achieved.

1. Reactive power management of wind integrated power system utilizing reactive power capability of wind turbine.
2. Reactive power regulation of wind integrated power system by incorporating FACT devices.
3. To adopt an intelligent control strategy for reactive power control of wind farm in case the conventional controller is not able to provide adequate performance.

5. METHODOLOGY:

To achieve the above mentioned objectives, a model of variable speed generator wind farm has to be developed using Sim Power system (MATLAB/SIMULINK). Vector control approach has to be implemented to control the active and reactive power independently through RSC and GSC. Stator flux oriented control and grid flux oriented control is to be implemented to control RSC and GSC respectively. The complete reactive power capability curve of wind generator has to be determined considering capability of RSC and GSC.

6. RESEARCH MOTIVATION:

Renewable energy based electrical power generation is the need of the day, not only to fill the gap of ever increasing demand and supply but also for environmental concerns. Wind energy generation is one of most promising and fast growing technology. Today, the penetration of wind energy has increased to a level that it start behave as conventional generation at some region in the world. So with the continuous technological improvement, it seems to be best alternative for conventional energy sources which will be ultimately in the favour of mankind.

7. WORK PLAN :

A) Study of reactive power control techniques of wind farms (20 months)

B) Development and Validation of the model for variable speed generator based wind farm (6months)

C) Implementation of the strategies of reactive power control utilizing Wind generator (6 months)

D) Incorporation of FACT devices in controlling the reactive power (6 months)

E) Implementation of Intelligent control strategy for reactive power control (6 months)

F) Documentation and Publication (in parallel) 24 months.

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