ABSTRACT

Renewable energy sources such as wind, solar, geothermal, tidal, and biomass are important energy sources. Production of power from renewable energy, promotes the economic status of a country. Among the various renewable energy sources, wind energy contributes the maximum and so the technologies used to extract power from wind is rapidly developing worldwide. The major elements of wind power generation systems are rotor, gearbox, brake, yaw drive system, controller, low speed and high-speed shafts. In order to enhance the efficiency of the wind generator, the controller needs to be optimized.

Generally, the load centers are located far away from the renewable power sources and so there is a need to transmit the power for long distances. The main problems associated with long distance transmissions are power fluctuations and Voltage Sag Ride Through (VSRT). As power fluctuations occur very frequently in India, this need to be addressed and it requires a proper procedure to overcome this situation.

In the current scenario, the wind turbines are simply disconnected from the grid during VSRT condition and reconnected back once the fault is recovered. This is a manual approach requiring more manpower and financial support. In order to optimize the utilization of the resources generated by a wind farm and to achieve the goals of sustainability and security of supply, the wind turbines should remain connected and actively support the grid even during VSRT.
The objective of this thesis is to investigate the improvements required in the Indian grid code and to design the Adaptive Internal Model Controller (AIMC) for grid connected Doubly Fed Induction Generator (DFIG) tolerant to VSRT.

DFIG is very popular in wind energy conversion system due to its variable speed, higher energy capture, efficiency, improved design, and separate controllability of grid side converter and rotor side converter. The system description is that the stator is directly connected to the constant frequency three-phase grid, and the rotor is connected with two back-to-back three-phase voltage source inverters with a common DC link. The main task of these converters is to convert the maximum available power from the wind. The Maximum Output Power Reference Approach (MOPRA) is considered for analysing the extraction of power from the wind energy.

In this research, the following investigations are carried out:

Review of International, Indian grid codes and power quality standards are presented and the improvements required for the Indian wind grid codes are proposed. Also, special requirements for VSRT are studied and the possible solutions are brought out. After a detailed review, it is concluded that congestion management procedures and power balancing controls are required in the Indian wind energy grid code.

The performance of AIMC is evaluated based on the DFIG response, such as stator and rotor flux, stator and rotor current, stator and rotor active power, stator and rotor reactive power, rotor speed and torque using
MATLAB/Simulink. In addition, both active and reactive powers are controlled at the same time using the AIMC and analyzed the changes in the DFIG operating conditions by varying the wind farm input wind speed.

The rotor side converter control without protection circuit for the fault ride through capability of the DFIG wind turbine is presented. Different adjustment mechanisms such as MIT Rule, Lyapunov theory, FuzzyMIT and AnfisMIT are directly applied in DFIG using model free and model reference AIMC. Simulation of these adjustment mechanisms for both fixed and variable gains are performed, and it is observed that AnfisMIT with variable gain adjustment mechanism yields better performance compared to fixed gain adjustment mechanism.

At the time of fault, single pulse dither signal is superimposed on the current loop to improve the performance in model free and model reference AIMC and a comparison is performed for different adjustment mechanisms.

The most vital part of this research work is that, precise information about the accurate model of the generator is not required as adaptive control techniques are used and it is proved that the adjustment mechanism has a greater influence in the VSRT.

It is recommended that the VSRT during long distance transmission can be improved using AIMC controlled DFIG with variable gain adjustment mechanism. The variable gain adjustment mechanism yields better performance compared to fixed gain adjustment mechanism by reducing the voltage dip, initial transients, final transients and rotor speed.