ABSTRACT

The present research focuses on developing certain proposed heuristic intelligent controllers inspired by nature to carry out effective control action and to handle the fault ride-through of grid connected wind turbines, which are connected along with doubly fed induction generators.

For the past decade, Doubly Fed Induction Generators (DFIG) are noted to occupy the world's largest share of wind turbines as a variant to traditional variable speed generators. The designed system should be in a position to operate over a wide range of wind speed for achieving optimal efficiency in order to follow the optimal tip-speed value. Henceforth, the generator's rotor is to be designed to operate in a variable rotational speed. DFIG are therefore designed to operate under both super and sub synchronous modes with a speed range of the rotor to be in accordance with that of the synchronous speed. The stator circuit module is connected directly to the grid; on the other hand the rotor windings are connected through a three-phase converter. In this research contribution, novel intelligent controllers are proposed which makes the DFIG based system of high stable nature and the simulation of the designed system is carried out choosing appropriate turns ratio.

The proposed research works in this thesis are of five modules i.e., the contributions involve developing three proposed population based stochastic evolutionary optimization algorithms hybridized with neural network architectures for performing control action handling the fault occurrence of the grid connected wind turbine along with DFIG, the remaining two modules involves developing fuzzy spiking neural network

and real coded genetic algorithm based fuzzy system to perform the action to control the reactive power to the grid.

Firstly, this research proposes a novel heuristic based controller module employing differential evolution and neural network architecture to improve the low-voltage ride through rate of grid connected wind turbines, which are connected along with DFIG. The controller designed in this contribution enhances the DFIG converter during the grid fault and this controller takes care of the ride-through the fault without employing any other hardware modules. The simulated results prove the effectiveness of the controller design and found to be better than that of the methods available in the literature.

Secondly, a novel hybrid Particle Swarm Optimization (PSO) - Group Search Optimizer (GSO) based Spiking Neural Network (SNN) which improves the low-voltage ride through rate of grid connected wind turbines that are connected along with doubly fed induction generators. The proposed controller in this contribution also aims to take care of the fault without employing any hardware module. This contribution is applied for the same wind farm case study as used to validate the previous approach. The simulated results prove the effectiveness of the controller design in comparison with that of the methods available in the literature and that of the previous proposed controller.

Thirdly, a Fuzzy based Spiking Neural Network (FSNN) controller is proposed in this thesis to control the reactive power and eliminate the additional hardware modules required for controlling the fault at the grid. Basically, spiking neural network converts the given input data sample into pulses based on the firing times incurred. This incorporation has resulted in effective solutions on the active and reactive power component of the grid connected DFIG with a control on speed of the rotor as well at the time of fault. The simulation results prove the effectiveness of the FSNN controller to be better in comparison with the other proposed controllers and that available in the literature.

Fourthly, an ELMAN neural network is modelled employing imperialist competitive algorithm to handle the fault ride through of the grid connected wind turbines. In ELMAN neural network, the weights are tuned optimally using the Imperialist Competitive Algorithm (ICA) model. It can be noted from the simulation results that the proposed controller has minimized the fitness function to a considerable extent and has also eliminated the additional hardware requirements employed with that of the traditional controller.

Finally, a fuzzy controller module is proposed in this thesis whose membership functions are optimized employing the developed variant of real coded genetic algorithm to handle over voltage ride through of grid connected DFIG. This fuzzy controller activates with formulation of rule base to give signal along with the q-component of the rotor current and eliminate the additional hardware circuitry required. Hence, with all the proposed controllers in this thesis, Real Coded Genetic Algorithm (RGA)-Fuzzy controller outperforms and results in better control strategy at the time of fault and also in general conditions. The simulation results prove the effectiveness of the proposed RGA-Fuzzy controller to be better in comparison with that of the methods available in the literature and as well that of the methods proposed earlier in this thesis.

The proposed controller modules are simulated in MATLABR2009 environment and executed in Intel Core2 Duo Processor with 2.27GHz speed and 2.00GB RAM. The converter modules are developed in Simulink environment of MATLAB. To validate all the proposed controller modules, a case study of wind farm with 1.5MW wind turbines connected to a 25 kV distribution system exporting power to a 120 kV grid through a 30 km 25 kV feeder is considered. Simulations are carried out with Differential Evolution based Inertia Double Wavelet Neural Network(DE-IDWNN)Controller, Hybrid PSO-GSO Controller, FSNN Controller, ICA-ELMAN model and RGA-Fuzzy Controller model to achieve effective solutions on the active and reactive power components of the grid connected DFIG with a control on speed of the rotor during the time of fault.