Implementation of Fuzzy Logic Control System to Enhance Stability of a Grid Connected Wind Farm: A Review

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Abstract— Power systems are the most complicated systems and have tremendous importance in modern life. They have direct impacts on the modernization, economic, political and various social aspects. Major blackouts and failures of power system depicts that voltage instability problem has been one of the main reasons of these disturbances and networks collapse. In recent years, fabulous and huge improvements have been achieved because of electric energy generation by utilization of wind energy. However, these achievements are accompanied by several issues for example grid stability and security. The transient stability issues of the grid connected wind farms have increased especially in case of severe disturbances and contingences. Static analysis is used to analyze the voltage stability of the system under study, while the dynamic analysis is used to evaluate the performance of compensators. The static techniques used are Power Flow, V– P curve analysis, and Q–V modal analysis. In this study, Flexible Alternating Current Transmission system (FACTS) devices- namely, Static Synchronous Compensators (STATCOMs) and Static Var Compensators (SVCs) - are used as reactive power compensators. There are diverse techniques to compensate reactive power which are generated by circuits.

Keywords—*Fuzzy, FACTS, STATCOM, ANN, Ultra Capacitor*

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I. INTRODUCTION

Wind power and its potential that can be harnessed in the future to meet the current energy demand. With detailed description of the wind turbine and the wind generator focus has been given on the interconnection of the generators with the grid and the problems associated with it. The use of power electronics in the circuitry and their applications has also been emphasized. In the end a voltage stability analysis has been done with respect to various models of the wind turbines to find the best way to clear faults and have optimum output. Increasing of power demands and economic growth as well as the rapid increase of CO2 emission which creates the global warming problem have stimulated the desire for renewable energy sources like wind energy, solar energy etc.
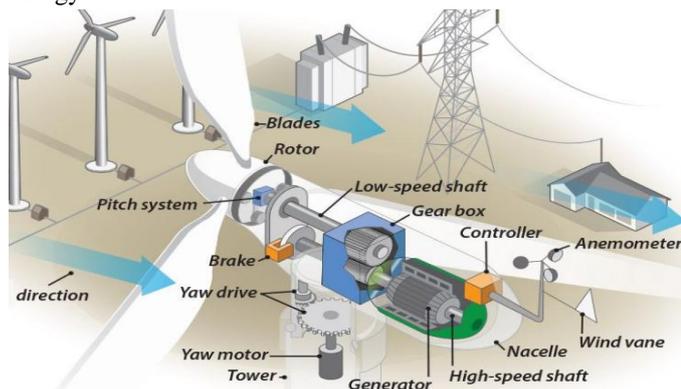

Figure 1 Wind turbine Working Principle

Electric power generation using wind turbines has attracted the attentions of utilities due to high generation capacity and low maintenance and cost of such turbines. The most common type of wind turbine is the fixed speed turbine with squirrel cage induction generator directly connected to the grid. These wind turbines based induction generators require reactive power for compensation. The needed reactive power of induction generator can be provided either by the grid or self capacitor bank in parallel with the generator stator terminals [1]. If sufficient reactive power is not supplied, then the electromagnetic torque of wind generator decreases significantly. Then the difference between mechanical and electromagnetic torques becomes large and the wind generator and turbine speeds increase rapidly. As a result, the induction generator becomes unstable and it requires to be disconnected from the power system. However, the recent trend is to decrease the shut down operation because a shutdown of large wind farm can have a serious effect on the power system operation such as loss of generation and load demand, voltage and frequency variations, power imbalance [2]. If a disturbance occurs at the transmission line which connects the power system to a remote wind farm, the wind turbines usually do not participate in voltage or reactive power control; they are often disconnected and then reconnected after the power system restore the normal operating conditions [3]. With the recent development of FACTS devices, SVC and STATCOM have been used for transient stability augmentation of power system in order to

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support the power system voltage and reactive power during and after disturbances where they actually increase the electric torque produced by the fixed speed induction generators and makes generators less like to over-speed and thus to increase system stability [4].

II. MODELLING AND STRUCTURE OF FACTS DEVICES

For wind farm integration, this research study uses both the static var compensator (SVC) and the static synchronous compensator (STATCOM). Providing dynamic reactive power compensation using SVC and STATCOM can possibly raise the network voltage during and after fault. As a result, the electric torque produced by the fixed speed induction generator will increase. So, generators will over-speed and thus increasing system stability. A typical SVC configuration is shown in upper part of figure 2. It consists of a number of thyristor switched capacitors (TSC) shunted with a thyristor controlled reactor (TCR). Lower part of figure 2 shows a typical STATCOM, which consists of a voltage source converter (VSC) and coupling transformer connected in shunt with the AC system. STATCOM DC voltage is usually controlled to a fixed value so as to operate satisfactorily [8].
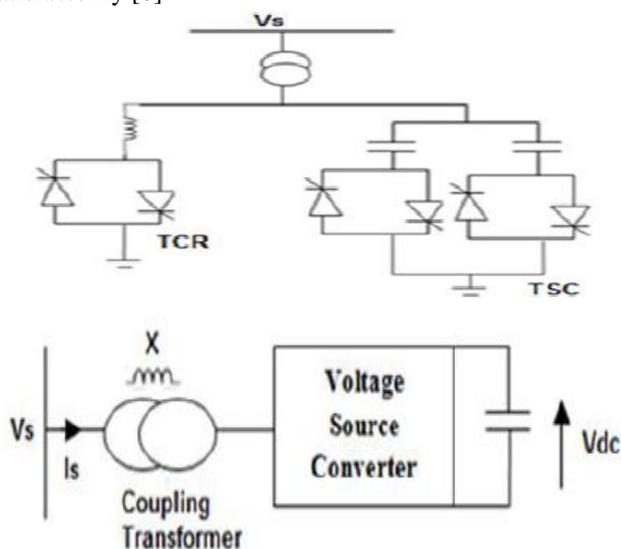

Figure 2 Diagrams of SVC and STATCOM [8]

III. PROBLEM BACKGROUND

Wind energy, without any doubt, offers the best advantages in regard to the environment and cost. However, it harbors some disadvantages worth putting into perspective if you intend to invest in wind energy. There are so many problem associated with the wind turbine out of which some of are listed below involves high upfront capital investment, visual impact, can reduce the local bird population, noise disturbances, takes up significant portion of land, safety concerns, suited to particular region and wind inconsistence. Some of problems are explained as: Wind energy has a lot in common with solar energy in terms of consistency. Although

wind energy qualifies as a renewable resource, wind speeds fluctuate each day. This can be a big disappointment to wind turbine developers who will commit every penny and every ounce of energy in the project only to end up with fluctuating wind patterns. This is why developers must do their research first to pinpoint the best location for setting up turbines before actual installation. The most hated disadvantage to wind turbines is the noise they produce. The sound produced by one turbine can be perceived from far distances. Combine many turbines, and the noise becomes unbearable. Many homeowners' lives have been turned upside down due to the noise pollution from turbines. In the last couple of decades, the frequency of tornadoes, hurricanes and cyclones have increased considerably. Now these severe storms can cause extensive damage to the wind turbines and can be a safety hazard to the people working in these wind farms. The damage may cause huge damage to wind turbines.

IV. RESEARCH METHODOLOGIES

There are various methodology will be used in this, which is Fuzzy logic and Artificial Neural Network, Ultra Capacitor, MPPT.

A. Artificial Neural Network (ANN)

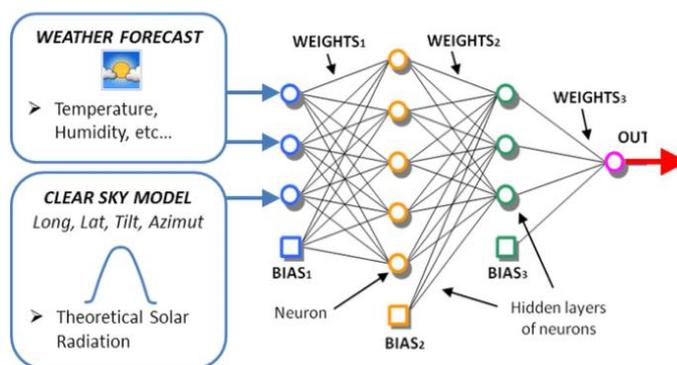We will start with understanding formulation of a simple hidden layer neural network.

Figure 3 Artificial neural networks Depiction

ANN is rarely used for predictive modeling. ANN is generally used in cases where what has happened in past is repeated almost exactly in same way. For example, say we are playing the game of Black Jack against a computer. An intelligent opponent based on ANN would be a very good opponent in this case (assuming they can manage to keep the computation time low). With time ANN will train itself for all possible cases of card flow.

B. Ultra Capacitor

The working of the super capacitor is given below: A super capacitor differs from an ordinary capacitor in two important ways: its plates effectively have a much bigger area and the distance between them is much smaller, because the

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separator between them works in a different way to a conventional dielectric. Like an ordinary capacitor, a super capacitor has two plates that are separated.
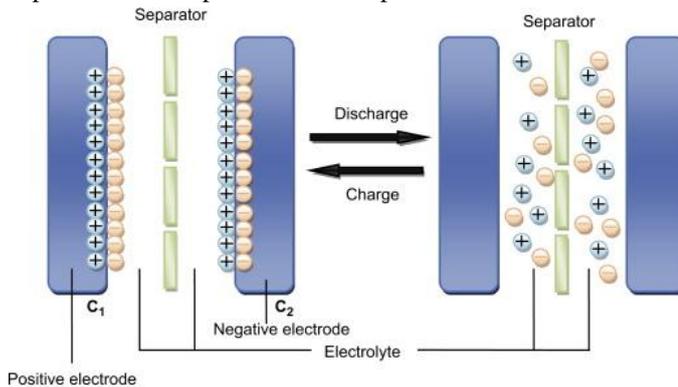

Figure 4 Super Capacitor Working

C. Fuzzy Logic

Fuzzy logic is a form of many-valued logic in which the truth-value of variables may be any real number between 0 and 1. By contrast, in Boolean logic, the truth-value of variables may only be the integer values 0 or 1. Fuzzy logic has been employed to handle the concept of partial truth, where the truth-value may range between completely true and completely false. Furthermore, when linguistic variables are used, these degrees may be managed by specific functions. Humans and animals often operate using fuzzy evaluations in many everyday situations.
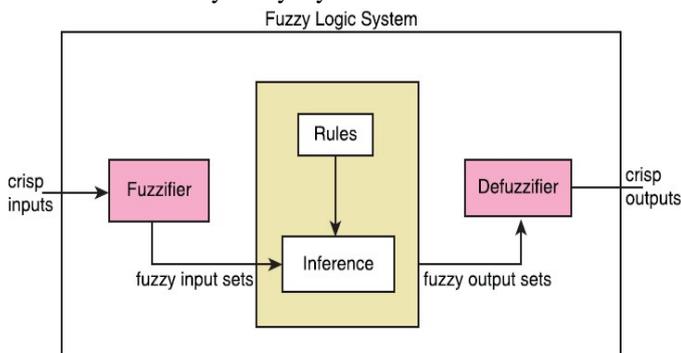

Figure 5 Fuzzy Logic

In the case where someone is tossing an object into a container from a distance, the person does not compute exact values for the object weight, density, distance, direction, container height and width, and air resistance to determine the force and angle to toss the object. Instead the person instinctively applies quick "fuzzy" estimates, based upon previous experience, to determine what output values of force, direction and vertical angle to use to make the toss.

V. CONCLUSION

With pace of time tremendous technology came into existence. Researcher always try to develop latest technology which will be beneficial for society having low cost, maximum efficiency and easy to understand. Wind power is the fastest growing renewable energy, it is essential to determine problems associated with maintaining a stable power system when it is connected to grid. Fast acting static synchronous compensator, a representative of FACTS family, is a promising technology being extensively used as the state-of-the-art dynamic shunt compensator for reactive power control in transmission and distribution system. In our research work proposed technique will be Fuzzy with PI controller so that reactive power can be generated and utilized in balance manner otherwise distortion will be came into existence. Over the last couple of decades, researchers and engineers have made path-breaking research on this technology and by virtue of which, many STATCOM controllers based on the self commutating. Solid state voltage-source converter (VSC) have been developed and commercially put in operation to control system dynamics under stressed conditions. Because of its many attributes, STATCOM has emerged as a qualitatively superior controller relative to the line commutating static VAR compensator (SVC).

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