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Study of Wind Energy System with Fuzzy Controlled Statcom

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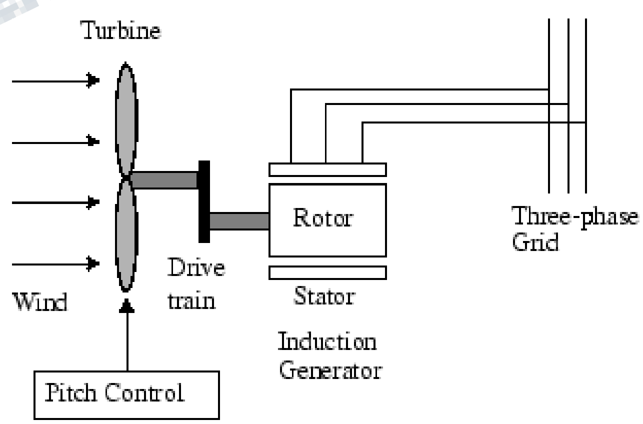
***Abstract*: -- The paper study shows the power quality problem due to the installation of a wind turbine with the grid. When the wind power is injected into the electric power system it has the stability problem. Fixed speed induction generators needed reactive power to maintain air gap flux. The Static Synchronous Compensator (STATCOM) near a wind farm is investigated for the purpose of stabilizing the grid voltage. The STATCOM is used with wind energy system at the point of common coupling to reduce power quality issues. The control scheme for grid-connected wind energy system with statcom is simulated using MATLAB for the purpose of power quality improvement in the power system. The simulation results reveal the performance of STATCOM in conjunction with PI controller. In this paper fuzzy logic controller is used instead of PI controller for reducing total harmonic distortion in the source current of the grid-connected wind energy generating system. For the power quality improvement of the grid-connected wind energy generating system a STATCOM control scheme is simulated using MATLAB the power system block set by using the Fuzzy logic controller.**

I. INTRODUCTION

With the increase in demand for Electricity due to increase in population and industrialization, the generation of power is really a challenge now a days. It is necessary to meet the energy needs by utilizing the renewable energy resources like wind, biomass, hydro co-generation, etc.he quality of power are increasingly matter to both end users and electric utilities of electric power . Power quality can be defined as "any power problem manifested in voltage, current and frequency those results in failure of the customer equipment".Voltage sag, swell, flickers; harmonics etc are main power quality issues.Use the induction generator connected directly to the grid is one of the simple methods of running a wind generating system . The induction generator has inherent advantages of cost effectiveness and robustness. However, induction generators require reactive power for magnetization. Absorbed reactive power and terminal voltage of an induction generator can be seriously affected when the generated active power of an induction generator is varied due to wind. Here proposing a STATCOM based control technology for mitigating the power quality issues when we are integrating wind turbine to the grid [1-2]. In this work we analyses the performance of STATCOM with a wind energy generating system connected at the point of common coupling with the existing power system to reduce the power quality issues . Conventionally, PI, are most popular controller and widely used in most power electronic appliances however recently there are many researchers reported successfully adopted Fuzzy Logic Controller (FLG) to become one of intelligent controller to their appliances. The introduction of change in voltage in the circuit will be fed to fuzzy controller for this proposes. This study demonstrates the power quality problems due to installation of wind turbine with the grid. PI controller plays an important role in reducing fluctuating voltage error signal efficiently. Simulation result shows that the proposed STATCOM with PI controller is efficient in reducing voltage sags and thus improving the power quality of the power grid. Fuzzy logic technique has been used as it has advantage of robustness, easily adaptive fast technology is also used and best results are achieved when compared to conventional PI technique.

II. WIND ENERGY GENERATING SYSTEM



In this configuration, wind generations are depend on constant speed analogy with pitch control turbine. The induction generator is used in the proposed scheme because of its simplicity, it does not require a separate field circuit, it can accept constant and variable loads, and has natural

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protection against short circuit. The available power of wind energy system is presented as under in Eq.1. [1]

$$P_{wind} = \frac{1}{2}\rho A V_{wind}^3 \quad (1)$$

Where _ρ̇' (kg/m) is the air density,
A is the area swept out by turbine blade in m2,
Vwind is the wind speed in m/s.
It is not possible to extract all kinetic energy of wind, thus it extract a fraction of power in wind, called power coefficient Cp of the wind turbine, and is given in Eq.2:

$$P_{mech} = C_p P_{wind} \quad (2)$$

Where Cp is the power coefficient, based on type and operating condition of wind turbine. This coefficient can be express as a function of tip speed ratio 'λ' and pitch angle 'θ' . The mechanical power produce by wind turbine is given in Eq. 3:

$$P_{mech} = \frac{1}{2}\rho \Pi R^2 V_{wind}^3 C_p \quad (3)$$

Where _R' is the radius of the blade in meters.

STATCOM (Static Synchronous Compensator)
The Static Synchronous Compensator (STATCOM) is a shunt device of the Flexible AC Transmission Systems (FACTS) family using power electronics to control power flow and improve transient stability of power grid. The STATCOM controls voltage at its terminal by controlling the amount of reactive power introduced into or absorbed from the power system. A STATCOM is analogous to an ideal synchronous machine, which generates a balanced set of three sinusoidal voltages at minimizing its environmental impact. the fundamental frequency with controllable amplitude and phase angle. This ideal machine has no inertia, is practically instantaneous, does not significantly alter the existing system impedance. When system voltage is low, the STATCOM injects reactive power (STATCOM capacitive). When system voltage is high, it absorbs reactive power (STATCOM inductive). This function is performed by means of a Voltage-Sourced Converter (VSC) fixed on the secondary side of a coupling transformer. The VSC uses forced-commutated power electronic devices (GTOs, IGBTs or IGCTs) to synthesize a voltage from a DC voltage source.

A STATCOM can improve power-system Performance like:

1. The dynamic voltage control in transmission and distribution systems,
2. The power-oscillation damping in power transmission systems,
3. The transient stability; and
4. The voltage flicker control; and
5. The control of both reactive power and (if needed) active power in the connected line, requiring a dc energy source.

III. SYSTEM PERFORMANCE

(a) PI Controller
The PI controller is suitable for second and lower order system. It can also be used for higher order plants with dominant second order behavior. The integral term in a PI controller causes the steady state error to zero. The Proportional Integral (PI) algorithm calculates and transfers a controller output signal every sample time to the final control element. The gains of PI controller can be selected by trial and error method. It performs lack of derivative action may make the system steadier in the steady state in the case of noisy data. PI controller have two tuning parameters to adjust parameters and integral action enables PI controller to remove offset, a major weakness of a P-only controller.

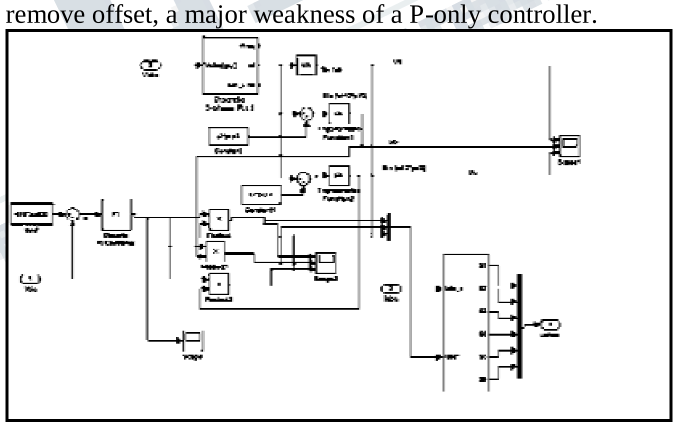

Fig.1 PI Controller connected in STATCOM

(b) Fuzzy Logic Controller
Fuzzy logic controller, proceed towards the human reasoning that makes use of the tolerance, uncertainty, imprecision and fuzziness in the decision-making process, manages to offer a very satisfactory performance, without the need of a detailed mathematical model of the system, just by incorporating the expert_s knowledge into fuzzy rules. In addition, it has built-in abilities to deal with noisy data thus, it is able to extend its control capability even to those operating conditions where linear control techniques fail. FLC voltage regulator is fed by one input that is voltage error (V) and another one is change in error (ΔE). The rules for the

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proposed FLC voltage controller are given table 1 shown below [7].

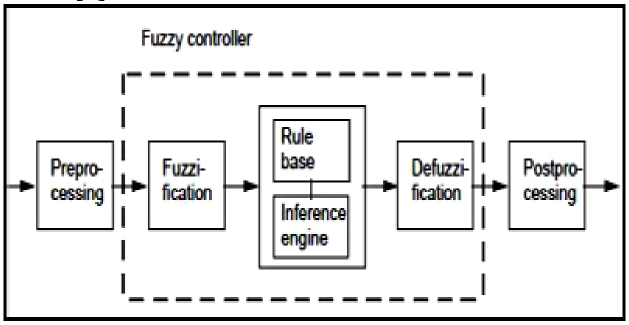

Fig. Basic Fuzzy Logic Operation

In this paper PI controller in AC Controller of STATCOM is replaced by Fuzzy Logic Controller to modify the overall output. Fig 1 indicates the PI controller implemented in STATCOM.

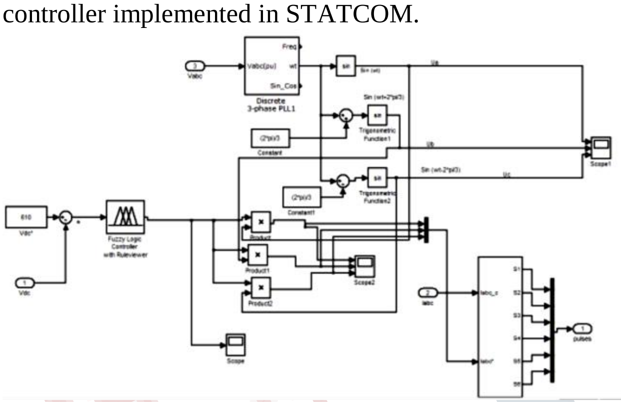

Fig.2 Fuzzy Controller Connected in STATCOM

Fig 1 indicates the Fuzzy Logic controller implemented in STATCOM.
The three main actions performed by a fuzzy logic controller are:

- Fuzzification
- Fuzzy processing
- Defuzzification

Fuzzification:- When the fuzzy controller receives the input data, it translates it into a fuzzy form. This process is called fuzzification.

De-fuzzification: It is the Process of converting fuzzifiedoutput into a crisp value. In the defuzzification operation alogical sum of the results from each of the rules performed.This logical sum is the fuzzy representation of the change in firing angle (output). A crisp value for the change in firing angle is calculated. Similarly the grid current changes and improves the power quality.

Fuzzy processing: - During fuzzy processing, the controller analyzes the input data, as defined by the membership functions, to arrive at a control output.

III. TEST SYSTEM MODEL

Studied wind farm in this paper has 6, 1.5 MW turbines.Thus the wind farm is having capacity of 9 MW. Mentioned units are connected to grid by a 400/25 kV transformer and a 25 kV, 2 lined distribution line with 25 km length and 132/25 kV transformer. Used generators in this model are squirrel cage induction generators and stator windings are directly connected to the grid and at the junction point in order to compensate part of required reactive power, capacitor bank is used. Simulated system model is shown in Fig 3 for STATCOM . This grid is used to study and analyze machine and wind farm stability

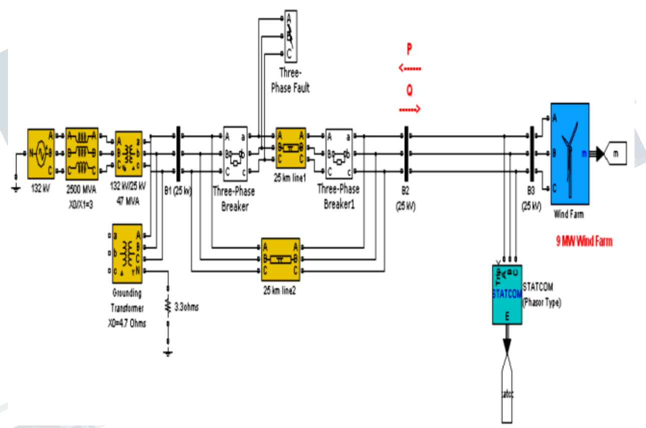

Fig.3 Test system model with STATCOM

IV. CONCLUSION

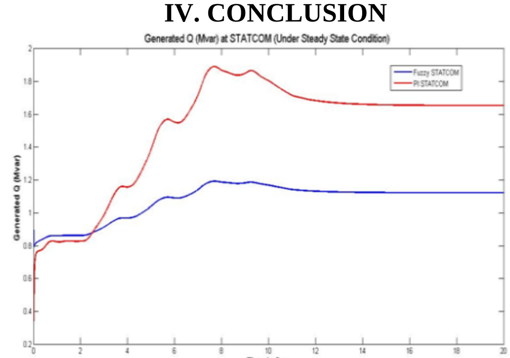

Fig. Generated Q (Mvar) at STATCOM under steady state condition

The operation of the STATCOM is simulated using two controllers: PI controller and Fuzzy controller. STATCOM injects current to the grid and it cancel out the reactive and harmonic parts of the induction generator current and load current. When we are reducing the wind generating system output, it will not affect the source current magnitude. In this project fuzzy logic controller based STATCOM is presented for grid connected wind energy generating system. The proposed FLC based STATCOM have improved the power quality of source current significantly by reducing the THD(Total Harmonic Distortion) from 5.79% to 1.45%.It is clearly presented that STATCOM with FLC gives better performance than STATCOM with conventional PI controller. For better voltage regulation Fuzzy-PI control technique showed better performance than the PI controller. One of the major advantages of the proposed FLC is being less sensitive to the system parameter variation; in addition, it is characterized by a negligible response time. Simulation result analysis has shown that the proposed controller has fast dynamic response, high accuracy of tracking the DC-voltage reference, and strong robustness to load sudden variations compared to the conventional PI controller. From the obtained result it is clear that STATCOM with Fuzzy Logic Controller gives improved results as compared to PI Controller. Thus it shows Power quality Improvement using Fuzzy Logic Controller.

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