Neural Network based Statcom for Grid Connected wind Generator

Dhanraj Meena[1], R.K.Gupta[2],Mahesh Verma[3]
[1]M.Tech Scholar, Gyan Vihar University, Jaipur, Rajasthan, India
[2] Professor, E.C.E Deptt., Gyan Vihar University, Jaipur, Rajasthan, India
[3]M.Tech Scholar, Gyan Vihar University, Jaipur, Rajasthan, India

Abstract:- Due to the increasing demand and restriction in building of the new lines complex modern power system presents serious challenges regarding stability of power system. Transient stability is also known as main source of the system insecurity. Because of that in the event of faults and disturbances it has to be maintained for power systems stable operation. In earlier power system to improve the transient stability supplementary controllers are used. These supplementary controllers are the shunt FACT devices like STATCOM (Static Synchronous Compensator) and SVC (Static VAR Compensator). Thesis suggests an application regarding NN (Neural Network). NN determines controller signal of STATCOM for grid active power and reactive power hence this improves stability of power system. Suggested controller is tested on 3-bus 2-machine system. The parameters like terminal voltage of buses, active power transmission line and reactive power of the system. The results which obtained are compared with the FLC system, Neural Network (NN). This proved that the Neural Network STATCOM gives better power result compare to that of STATCOM with FLC system. The effectiveness is verified by the Mat Lab/Simulink Software.

Keywords:- *STATCOM, FLC (Fuzzy Logic Control), NN (Neural Network), Transient Stability.*

*****

I. INTRODUCTION

A turbine could be a device that changes over K.E. (Kinetic Energy) from the wind into electric force. Turbine utilized for charging batteries is additionally expressed as a wind charger. The after effects of more than a thousand years of windmill advancement and popular building, today's wind turbines are processing plant made in a wide determination of vertical and flat pivot assortments. The most modest turbines are utilized for applications like battery charging for assistant force for pontoons or parades or to power movement cautioning signs. Marginally bigger turbines will be utilized for making commitments to a local force offer while promoting unused power back to the utility supplier by means of the electrical network. Varieties of huge turbines, called wind ranches, have turn into a dynamically essential supply of renewable vitality and are utilized by a few nations as a piece of a strategy to curtail their dependence on fossil energizes [1].

Obviously, wind vitality is high on the administrative and institutional motivation. On the other hand, there are a few impediments inside of the strategy for its broad. Wind turbines partner with entirely unexpected topologies, architectures and style choices. The schematic of a turbine era system is demonstrated in Fig. 3. A few decisions turbine topologies are as per the following [35].

Wind turning motors encapsulate indispensable mechanical components like turbine edges and rotors, generators and drive train. They cost over half hour of aggregate expense for seaward wind venture [24]. All in all, wind turbines are assumed for relatively difficult to reach locales putting a few limitations on the styles in an exceptionally assortment of how. For seaward situations, the area is likewise reasonably got to for upkeep once every year. Accordingly, adaptation to non-critical failure of the turbine is of significance for force station advancement. A hundred and eighty Advances in option vitality.

One of key components inside of the turbine is its drive prepares that connections mechanics rotor and electrical out-put terminals. Streamlining of turbine generators can't be finished while not considering mechanical, auxiliary, water powered and attractive execution of the drive train. A blueprint of the drive train advancements is delineated in Fig. 1.4 for correlation.

For the most part, they will be countermined into four mixtures in accordance with their structures:

• Conventional: apparatus case and rapid generator with few post sets.

• Direct commute: any commute train while not an apparatus case and low speed generator with a few shaft sets.
• Hybrid: any commute train with an apparatus case and in this way the generator speed between the higher than two sorts.

• Multiple generators: any commute train having more than single generator.

The drive-train-topologies could raise the issues like the blending of the rotor and gearbox/ direction, the segregation of substances and generator shafts from mechanical bowing masses, the uprightness and payload routines. In spite of the fact that it ought to be less demanding to administration

 ISSN: 2321-8169
5439 - 5444

separate turbine components like gearboxes, heading and generators, the exchange is dynamically for system style of the coordinated commute train components.

II. STATCOM

A Static Synchronous Compensator (STATCOM), moreover Called a "Static Synchronous Condenser" ("Statcon"), Could Be a control device utilized on power transmission systems. It bolstered an impact material science voltage source convertor and may go about as either a supply or sink of receptive AC energy to a power system. On the off chance that joined with a supply of force it may offer dynamic AC power. It's an individual from the FACTS group of devices. It's characteristically standard and electable.

Typically a STATCOM is put into bolster power arranges that have a poor force issue and some of the time poor voltage regulation. There are yet, different uses, the first basic utilization is for voltage solidness. A STATCOM could be a Voltage Source Convertor (VSC) based device, with the voltage supply behind a reactor. The voltage supply is framed from a DC electrical device thus a STATCOM has minimal dynamic force capacity. Then again, its dynamic force capacity will be swelled if a worthy vitality memory device is joined over the DC electrical device. The responsive force at the terminals of the STATCOM relies on upon the adequacy of the voltage supply. As an illustration, if the terminal voltage of the VSC is more than the AC voltage at the motivation behind association, the STATCOM produces receptive current; on the other hand, once the sufficiency of the voltage supply is under the AC voltage, it assimilates responsive force. The inert time of a STATCOM is shorter than that of a Static Var Compensator (SVC), essentially owing to the speedy change times gave by the IGBTs of the voltage supply convertor. The STATCOM furthermore gives higher receptive force support at low AC voltages than a SVC, since the responsive force from a STATCOM diminishes directly with the AC voltage (as the present will be kept up at the evaluated worth even the distance down to low AC voltage).

III. SYSTEM DESCRIPTION

The STATCOM is a shunt-connected reactive-power compensation device that is capable of generating and/ or absorbing reactive power and in which the output can be varied to control the specific parameters of an electric power system. It is in general a solid-state switching converter capable of generating or absorbing independently controllable real and reactive power at its output terminals when it is fed from an energy source or energy-storage device at its input terminals. Specifically, the STATCOM, which is a voltage-source converter which when fed from a given input of dc voltage, produces a set of 3-phase ac-output voltages, each in phase with and coupled to the corresponding ac system voltage through a relatively small reactance (which is provided by either an interface reactor or the leakage inductance of a coupling transformer).

The dc voltage is provided by an energy-storage capacitor. 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;
4. The voltage flicker control; and
5. The control of not only reactive power but also (if needed) active power in the connected line, requiring a dc energy source.

Furthermore, a STATCOM does the following:

1. It occupies a small footprint, for it replaces passive banks of circuit elements by compact electronic converters;
2. It offers modular, factory-built equipment, thereby reducing site work and Commissioning time;
3. It uses encapsulated electronic converters, thereby minimizing its environmental impact.

A STATCOM is analogous to an ideal synchronous machine, which generates a balanced set of three sinusoidal voltages at 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, and can internally generate reactive (both Capacitive and inductive) power. Control Scheme: The STATCOM is a static var generator whose output can be varied so as to maintain or control certain specific parameters of the electric power system. The STATCOM is a power electronic component that can be applied to the dynamic control of the reactive power and the grid voltage. The reactive output power of the compensator is varied to control the voltage at given transmission network terminals, thus maintaining the desired power flows during possible system disturbances and contingencies.

STATCOMs have the ability to address transient events at a faster rate and with better performance at lower voltages than a Static Var Compensator (SVC). The maximum compensation current in a STATCOM is independent of the system voltage. A STATCOM provides dynamic voltage control and power oscillation damping and improves the system‘s transient stability. By controlling the phase angle, the flow of current between the converter and the ac system are controlled. A STATCOM was chosen as a source for reactive power support because it has the ability to continuously vary its susceptance while reacting fast and providing voltage support at a local node.

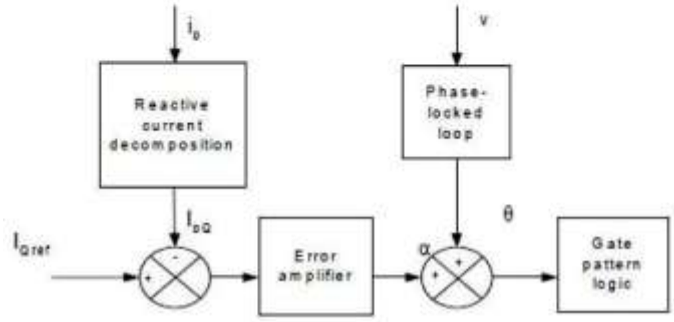

Fig. 1 Basic STATCOM control scheme

A STATCOM injects almost a sinusoidal current Io of variable magnitude at a point of connection. The injected current is almost in quadrature with the line voltage V, thereby emulating an inductive or a capacitive reactance at the point of connection with the transmission line. The functionality of the STATCOM model is verified by regulating the reactive current flow through it this is useful to generate or absorb reactive power for regulating the line voltage of the bus where the STATCOM is connected. Similarly when the system voltage is higher than the converter voltage, the system ―sees‖ an inductive reactance connected at its terminal. Hence, the STATCOM ―sees‖ the system as the capacitive reactance and the STATCOM is operating in an inductive mode. The current flows from the ac system to the STATCOM, resulting in the device absorbing reactive power. For an inductive operation the current lags the ac voltage by an angle of 90 degrees, by assuming that converter losses are neglected.

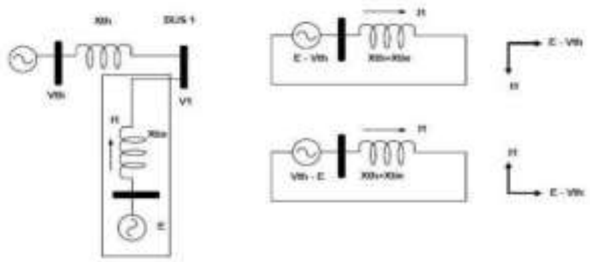

Fig. 2 A STATCOM operated in inductive and capacitive modes.

If the amplitude of the STATCOM output voltage and the ac system voltage are equal, the reactive current is zero and the STATCOM does not generate or absorb reactive power. Since the STATCOM is generating or absorbing only reactive power the output voltage of the converter, and the ac system voltage V are in phase when neglecting circuit losses. The ac current magnitude can be calculated by using the following equation

$$I_0 = \frac{V\ out - v}{X} \qquad (1)$$

By assuming current flows from converter to the ac system. X is represented as the coupling transformer leakage reactance. The corresponding reactive power exchanged can be expressed as

$$Q = \frac{V_{Out}^2 - V_{out}\ V\ Cos\ \alpha}{X}$$

Where angle α is the angle between the ac system bus voltage and the converter output voltage.

The working principle of the wind turbine includes the following conversion processes: the rotor extracts the kinetic energy from the wind creating generator torque and the generator converts this torque into electricity and feeds it into the grid. Presently there are three main turbine types available. They are

- Squirrel-cage induction generator
- Doubly fed induction generator.
- Direct-drive synchronous generator.

The first one which is the simplest and oldest system consists of a conventional directly grid-coupled squirrel cage induction generator. The slip, and the resultant rotor speed of the Generator varies with the amount of power generated . The rotor speed variation is small, approximately 1% to 2%, and hence this is normally referred to as a constant speed turbine. The other two generating systems are variable –speed systems. In the doubly fed induction generator, a back to back voltage source converter feeds the three phase rotor winding, resulting that the mechanical and electrical rotor frequency are decoupled and the electrical stator and rotor frequency can match independently of the mechanical rotor speed. In the direct-drive synchronous generator, the generator is completely decoupled from the grid by power electronics, as a converter is connected to the stator winding and another converter is connected to the grid. Thus the total power delivered by the wind power is transmitted by an HVDC link. In this paper, the configuration of wind generator is based on constant speed topologies 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 protection against short circuit. The available power of wind energy system is given by the equation,

$$P_{wind} = 1/2\ \rho\ A\ V^3_{wind} \qquad (3)$$

Where ρ (kg/m3) is the air density, A (m2) is the area swept out by turbine blade, is the wind speed in m/s. It is not possible to extract all kinetic energy of wind, thus it extracts a fraction of power in wind, called power coefficient Cp of the wind turbine, and is given by the following equation

$$P_{mech} = C_P P_{wind} \quad (4)$$

where Cp is the power coefficient, depends on type and operating condition of wind turbine. This coefficient can be expressed as a function of tip speed ratio and pitch angle. The mechanical power produced by wind turbine is given by the following equation

$$P_{mech} = 1/2\ \Pi\ \rho\ R^2 V_{wind}^3\ Cp \quad (5)$$

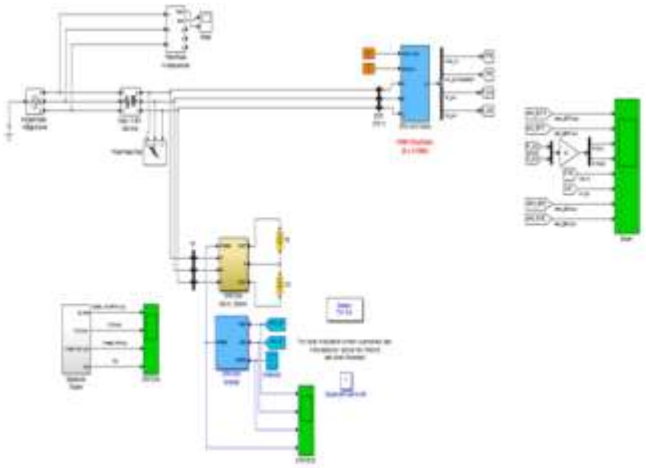

Fig 3 :- Design model

The system is design for 3 bus 2 machine system . Introducing a fault system for the three phase power distribution system .In the STATCOM controller , introducing the fuzzy logic in the voltage regulator .Voltage regulator contain the fuzzy and neural network .Fuzzy logic is able to improve the performance of the complex power .

$$\text{Complex power} = \sqrt{(\text{Real Power})^2 + (\text{Reactive Power})^2}$$

In a simple alternating current (AC) circuit consisting of a source and a linear load, both the current and voltage are sinusoidal. If the load is purely resistive, the two quantities reverse their polarity at the same time. At every instant the product of voltage and current is positive or zero, with the result that the direction of energy flow does not reverse. In this case, only active power is transferred.

If the loads are purely reactive, then the voltage and current are 90 degrees out of phase. For half of each cycle, the product of voltage and current is positive, but on the other half of the cycle, the product is negative, indicating that on average, exactly as much energy flows toward the load as flows back. There is no net energy flow over one cycle. In this case, only reactive power flows there is no net transfer of energy to the load.

$$Q = V\ I\ \text{Sin}\theta$$

$$\text{Reactive Power} = \sqrt{(\text{Apparent Power}^2 - \text{True power}^2)}$$

$$\text{VAR} = \sqrt{(\text{VA}^2 - \text{P}^2)}$$

$$\text{kVAR} = \sqrt{(\text{kVA}^2 - \text{kW}^2)}$$

The product of voltage and current if and only if the phase angle differences between current and voltage are ignored.
Total power in an AC circuit, both dissipated and absorbed/returned is referred to as apparent power .The combination of reactive power and true power is called apparent power

In an AC circuit, the product of the r.m.s voltage and the r.m.s current is called apparent power.
It is the product of Voltage and Current without phase angle

The unit of Apparent power (S) VA i.e. 1VA = 1V x 1A.

When the circuit is pure resistive, then apparent power is equal to real or true power, but in inductive or capacitive circuit, (when Reactance's exist) then apparent power is greater than real or true power.

IV. PROPOSED METHODOLGY

The simplest definition of a neural network, more properly referred to as an 'artificial' neural network (ANN), is provided by the inventor of one of the first neuro computers, Dr. Robert Hecht-Nielsen. He defines a neural network as:

"...a computing system made up of a number of simple, highly interconnected processing elements, which process information by their dynamic state response to external inputs.
ANNs are processing devices (algorithms or actual hardware) that are loosely modeled after the neuronal structure of the mamalian cerebral cortex but on much smaller scales. A large ANN might have hundreds or thousands of processor units, whereas a mamalian brain has billions of neurons with a corresponding increase in magnitude of their overall interaction and emergent behavior. Although ANN researchers are generally not concerned with whether their networks accurately resemble biological systems, some have. For example, researchers have accurately simulated the function of the retina and modeled the eye rather well.

To better understand artificial neural computing it is important to know first how a conventional 'serial' computer and it's software process information. A serial computer has a central processor that can address an array of memory locations where data and instructions are stored. Computations are made by the processor reading an instruction as well as any data the instruction requires from memory addresses, the instruction is then executed and the results are saved in a specified memory location as required. In a serial system (and a standard parallel one as well) the computational steps are deterministic, sequential and logical, and the state of a given variable can be tracked from one operation to another.

In comparison, ANNs are not sequential or necessarily deterministic. There are no complex central processors, rather there are many simple ones which generally do nothing more than take the weighted sum of their inputs from other processors. ANNs do not execute programed instructions; they respond in parallel (either simulated or actual) to the pattern of inputs presented to it. There are also no separate memory addresses for storing data. Instead, information is contained in the overall activation 'state' of the network. 'Knowledge' is thus represented by the network itself, which is quite literally more than the sum of its individual components. Neural Network is introducing in the STATCOM system for improve the complex power . After apply Neural; network system is getting more active power by that behalf, more complex power is getting . In the STATCOM design introducing a switch which is using for select the controller . System is working for both Fuzzy and Neural Network controller .

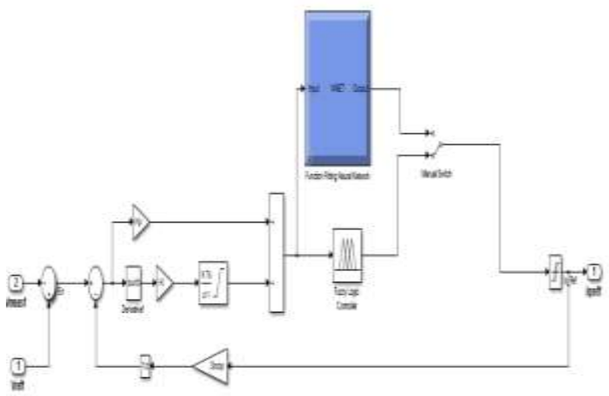

Fig 4:- STATCOM Voltage Controller from Fuzzy and Neural Network

The results are getting improved of active power and reactive power by Neural Network .

V. RESULTS

STATCOM is working for the two controllers fuzzy and neural network . Results are showing the values of the active and reactive power . Active power and reactive power gives the output of the complex power .

Active power is show in the graph by P and reactive power is show in the graph by Q . Q is measure in VER(Volt -Ampere Reactive).

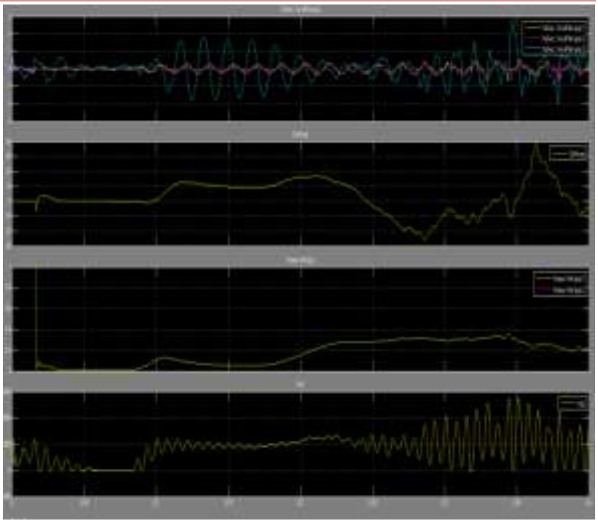

Fig 5 :- Fuzzy Logic controller Output

Fuzzy logic controller gives the reactive power Q(mar) -5 and active power value is 0.2 . According to formula

Complex power = $\sqrt{(\text{Real Power })^2 + (\text{Reactive Power })^2}$

Real power = 0.35

Reactive power = -12

Complex Power = $\sqrt{(0.35\,)^2 + (-12)^2}$

Complex power = 12.005103 KVA

Neural network is able to improve the performance of the active and reactive power .

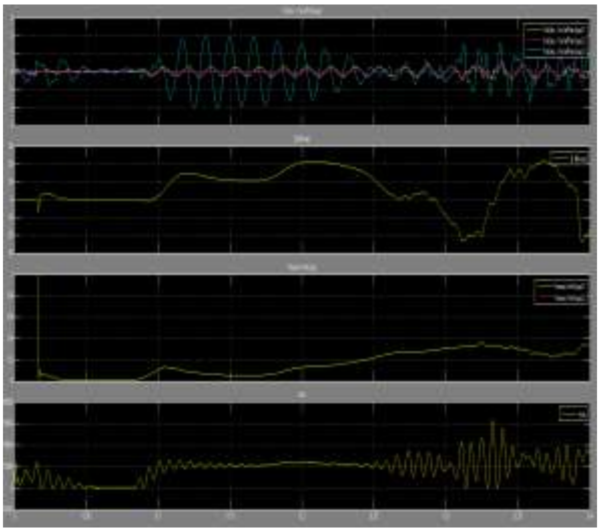

Fig 6 :- Neural Network Controller output

Complex power = $\sqrt{(\text{Real Power })^2 + (\text{Reactive Power })^2}$
Real power = 0.35 KW
Reactive power = - 18 KVAR

Complex Power = $\sqrt{(0.35\,)^2 + (-18)^2}$

Complex power = 18.0034 KVA

VI. CONCLUSION

In this Thesis Neural Network based STATCOM is presented for grid connected Wind Energy Generating System. The proposed Neural Network based STATCOM have improved the power quality of source current. Results are comparing from the Fuzzy logic controller . Fuzzy logic gives the complex power of 12.005103 KVA while Neural Network is giving the complex power of 18.003 KVA . It is clearly presented that STATCOM with Neural Network gives better performance than STATCOM with Fuzzy Logic controller.

For further improve the performance of the system , Reactive power can be reduce by use fuzzy PID controller .STATCOM grid connection gives more active power if the reactive power will reduce .

REFERENCES

[1] Sharad W. Mohod, Mohan V. Aware,‖ A STATCOM-Control Scheme for Grid Connected Wind Energy System for Power Quality Improvement, IEEE SYSTEMS JOURNAL, VOL. 4, NO. 3, SEPTEMBER 2010,

[2] EWEA,‖ Wind Energy Statistics‖, 2008.

[3] Claudio L.Souza et. al.,: "Power System Transient Stability Analysis Including Synchronous and Induction Generator", IEEE porto Power Tech Proceedings, Vol.2, pp.6, 2001.

[4] I. Erlich, F. Shewarega, J.L. Rueda ―Impact of Large Offshore Wind Farms on Power System Transient Stability‖, PSCE, 2009.

[5] Mrs. M. Mohammadha Hussaini & Dr. R. Anita, ―The Study of Dynamic Performance of Wind Farms with the Application of a STATCOM and its Effect‖ in International Journal of Recent Trends in Engineering, Vol 2, No. 6,November 2009, page no.158-160.

[6] M.Mohammadha Hussaini, Dr. R. Anita, ― Dynamic Response of Wind Power Generators using STATCOM ― in International Journal of Engineering and Technology Vol.2 (4), 2010, 297-304.

[7] H. Karimi-Davijani, A. Sheikholeslami, H. Livani and M. Karimi-Davijani, ―Fuzzy Logic Control of Doubly Fed Induction Generator Wind Turbine‖, in World Applied Sciences Journal 6 (4): 499-508, 2009.

[8] I. Prabhakar Reddy, B.V. Sanker Ram, ―STATCOM with FLC for Damping of Oscillations of Multi machine Power System‖ in Journal of Theoretical and Applied Information Technology