ANN Based Tuning of STATCOM in a Distributed Generation System

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Abstract— In Recent trends integration of Distributed Generation (DG) units in the distribution system is one of the major concerns for electrical power system. The voltage control for small DG units in the grid is kept in the standard limit. There is lack in reactive power support that brings the problem of slow recovery and it leads to the usage of expensive Flexible AC Transmission System (FACTS) devices such as static synchronous compensator (STATCOM). STATCOM has been placed at the bus which requires reactive power control. Soft computing method of ANN's is used for the prediction of voltage stability problems of the proposed systems. The training for the NN controller is done by using Back Propagation algorithm. It is obtained from MATLAB simulation results with the proposed ANN based tuning of STATCOM has effectively achieved the fast voltage recovery and power factor improvement.

Key words: Distributed Generation (DG), Static Synchronous Compensator (STATCOM), Artificial Neural Network (ANN)

I. INTRODUCTION

In recent years, environmental and commercial concerns have led to worldwide large-scale Distributed-Generation (DG) integration. DG units have many advantages, especially, reduced losses as well as improved grid security and reliability. However, the penetration of DG units into the existing grid poses challenges to the utilities due to two-way power-flow and different characteristics compared to the conventional generators. DG systems are usually powered by solar, wind, landfill gas, diesel engines, natural gas micro-turbines, etc. DG refers to an electrical generating facility located on customer's premise and owned by the customer, which may be operated in parallel with the utility [1]. The risk of voltage collapse for lack of reactive power support is one of the major problem in power system.so low voltage ride through (LVRT) capability is one of the most demanding requirements that have been included in the grid codes [2].The FACTS devices can assist grid integration of DG units by supplying dynamic VAR under post fault condition [3-5].STATCOM is used to maintain reactive current output at its nominal value over a wide range of bus voltages. By placing STATCOM at the point of common coupling voltage under abnormal and continuous condition can be improved, ultimately allowing DG units to remain connected to the grid. Particle Swarm Optimization method to solve the optimal allocation and sizing of multiple STATCOM [6-8]. Costs can be reduced by reducing the rating of STATCOM along with an appropriate combination of capacitors. The objective of reactive power planning is the determination of the new VAR sources that will result in an adequate voltage control capability by achieving a correct balance between security and economic concerns [9]. The main important features which can be credited to ANN are its ability to learn non-linear problem with selective training which can lead sufficiently accurate on line response. On choosing ANN, selection of input and training are the important aspects [10].Under normal operating conditions the rating of STATCOM as well as other FACTS devices is chosen based on the power factor and voltage requirements at the Point of Common Coupling.

This paper presents a STATCOM has been placed at the bus which requires reactive power control. Soft computing method of ANN's is used for the prediction of voltage stability problems of the proposed systems. The training for the NN controller is done by using Back Propagation algorithm. It is obtained from MATLAB simulation results with the proposed ANN based tuning of STATCOM has effectively achieved the fast voltage recovery and power factor improvement. The paper is organized as follows. The system configuration is discussed in section II. ANN based tuning is given in section III. Section IV gives the results and discussion and section V conclude the paper.

II. SYSTEM CONFIGURATION

STATCOM is a Voltage-Source Converter (VSC)-based FACTS device. The function of STATCOM is to exchange dynamic reactive power with the ac system. In DG system, STATCOM applications have been found in voltage regulation and stabilization. The Block Diagram of STATCOM with ANN is shown in Fig.1. Each phase of the VSC is connected to the ac system via series RL branch representing coupling transformer leakage impedance. The ac system is modelled by an ideal three-phase voltage source. The current-mode control is performed in dq-frame as also illustrated in Fig.1. Both the feedback and feed forward signals are first transformed to dq-frame and then processed by compensators to generate the control signals in dq-frame. The reference signals for real and reactive power are denoted as P_{sref} and Q_{sref} respectively and are fed to the reference signal generator.

STATCOM is connected to the ac source system. The STATCOM generates the output dc voltage (Vdc). The ANN block receives the input from STATCOM and Vpcc. Vpcc is taken between the source and load. The ANN gives the reference voltage to control the signals generated from the PWM generator.

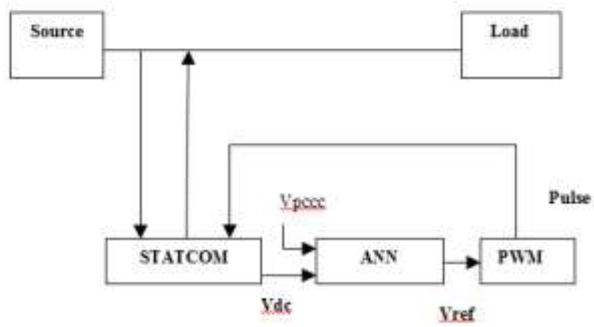

Fig. 1: Block Diagram of STATCOM with ANN

A. STATCOM

The Static synchronous compensator is one of the key FACTS devices. Based on a voltage source convertor, the STATCOM regulates system voltage by absorbing or generating reactive power. Contrary to a Static Var Compensator (SVC), STATCOM's inductive current (or) capacitive current can be controlled independent of the AC system voltage. STATCOM consists of coupling transformer, VSC and dc energy storage device as shown in Fig.2.

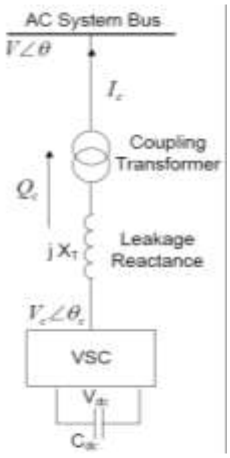

Fig.2: Model of STATCOM

STATCOM is capable of exchanging reactive power to the transmission line because of its small energy storage device i.e. small dc capacitor, dc capacitor is replaced by dc storage battery or other dc voltage source and the controller can exchange real and reactive power with the transmission system, extending its region of operation from two to four quadrants.

B. Equivalent circuit of STATCOM

A static synchronous compensator (STATCOM) is a regulating device used on alternating current electricity transmission networks. It is based on a power electronics voltage-source converter and can act either as a source or sink of reactive AC power to an electricity network STATCOM reactive power output is independent of voltage magnitude – i.e. Constant current even under low voltage limit. With the commercial breakthrough of high power gate turn-off devices, the road is paved for an additional step forward inflexibility of AC transmission and distribution systems: STATCOM, or the Static Synchronous Compensator. The name is an indication that STATCOM has a characteristic similar to the synchronous condenser, but as an electronic device it has no inertia and is superior to the synchronous condenser in several ways, such as better dynamics, a lower investment cost and lower operating and maintenance costs. The use of a STATCOM is that the reactive power provision is independent from the actual voltage on the connection point .A STATCOM structure is based on Voltage Sourced Converter (VSC) topology and utilizes either Gate-Turn off Thyristor (GTO) or Isolated Gate Bipolar Transistors (IGBT) devices. The STATCOM is a very fast acting, electronic equivalent of a synchronous condenser. The equivalent circuit of STATCOM is shown in Fig.3.

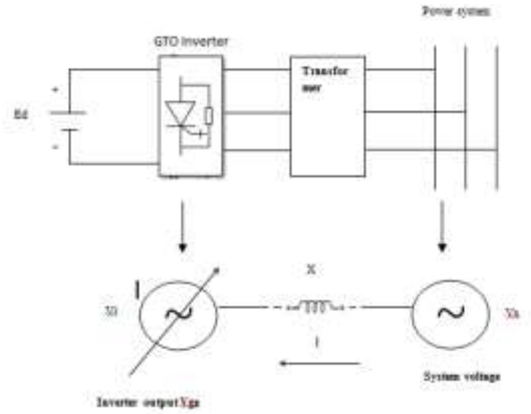

Fig. 3: Equivalent circuit of STATCOM

The GTO converter with a dc voltage source and the power system are illustrated as variable ac voltages in this figure.

III. ARTIFICIAL NEURAL NETWORK

A. ANN Architecture and Functions

A neural net is an artificial representation of the human brain that tries to simulate its learning process. An Artificial Neural Network also called as Neural Network or simply the Neural Net. Traditionally the word Neural Network refers to a network of biological neurons in the nervous system that process and transmits information. ANN is organized by a group of artificial neurons that uses a mathematical model or computational model for information processing based on a connectionist approach to computation.
The steps involved in ANN are,

1) A set of input connections brings in activations from other neurons.
2) A processing unit sums the inputs and then applies a non-linear activation function i.e., squashing / transfer / threshold function.
3) An output line transmits the output to other neurons.

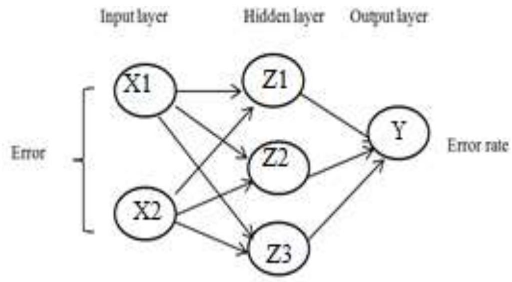

Fig. 4: Simple neuron structure

The input and output data required to train the ANNs are current and point of common coupling voltage. Supervised learning algorithm is used as testing algorithm generator to achieve the target. In this project on choosing the random weight initially and get the corresponding output. The method checks the output to the target; whether any difference means the error in the achievable target it will train the output on back propagation still to achieve the correct or approximate target.

B. Back Propagation Algorithm

Back propagation learning is the commonly used algorithm for training the multi-layer perceptron. The back propagation algorithm is used to train the network for interment the nonlinear mapping between the input variable and output variable. By using the back propagation learning rule the network weights are adjusted during the training. The mean square error is introduced as the training period, to evaluate the effectives of the training network. The performance and accuracy of the network is the better while mean square is lesser. The training set and its algorithm is effective, then the network able to correctly estimate the output through the input is not relevant to the training set. This occurrence called as generalization. The application of neural network involves two distinct levels: Training and testing. In training level the network weights are implemented to reflect the problem domain and in testing phase, the weights have been unmoving and the network when presented with test data will forecast the correct output. The current and voltage are feed as input to neural network. The hidden layer neuron is tangent hyperbolic functions.

C. D-Q Control Theory

The conversion of the three phase voltage into DC quantities like V_d and V_q in the rotating frame is known as DQ transformation. The DQ theory is used to develop a controller that can be used to control the real and reactive power components independently.

IV. RESULTS AND DISCUSSION

MATLAB is a high performance language for technical computing. The Simulink model of reactive power management of DG system by tuning STATCOM is shown in Fig.8.

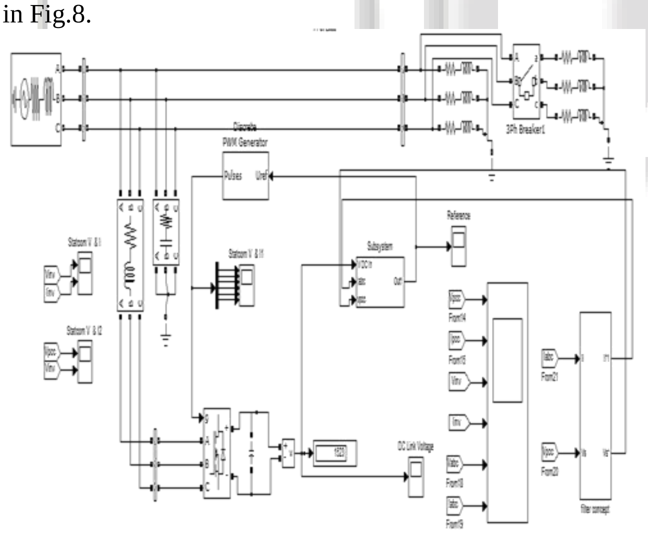

Fig. 5: Simulink Model of Reactive Power Management of DG System by tuning STATCOM

In Fig.8 describes STATCOM connected to an AC system. In which STATCOM consist of voltage source inverter (VSC), coupling transformer and capacitor. Each phase of the VSC is connected to the ac system via series RL branch representing coupling transformer leakage impedance. Capacitor is an energy storage device. In initial condition source and demand must be equal. Transformer is connecting the source through RL branch. If the demand increases, feedback power to the STATCOM in which capacitance injects the power. If the demand decreases, feedbacks power to the STATCOM in which in inductance store the power.

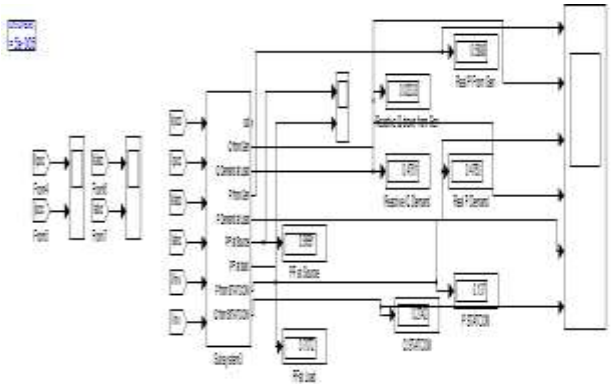

Fig. 6: Simulink model for showing power factor

In source side I got the compensated voltage. But current is not compensated. On load side the voltage and current are trying to compensate by injecting the reactive through STATCOM.

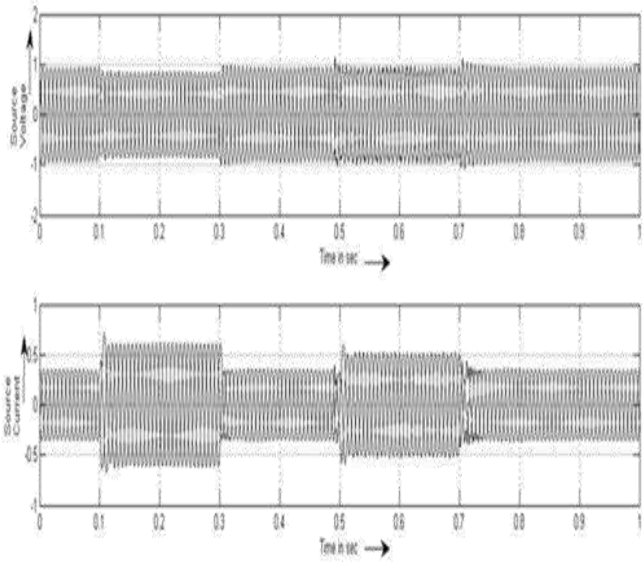

Fig. 7: Voltage and current waveform in source side

In Fig.9 defines initially source voltage is maintained at 1 p.u and current value maintained at 0.4 p.u. Voltage is decreased to 0.8 p.u at 0.1-0.3 seconds. At that time current level suddenly increased to 0.5 p.u.

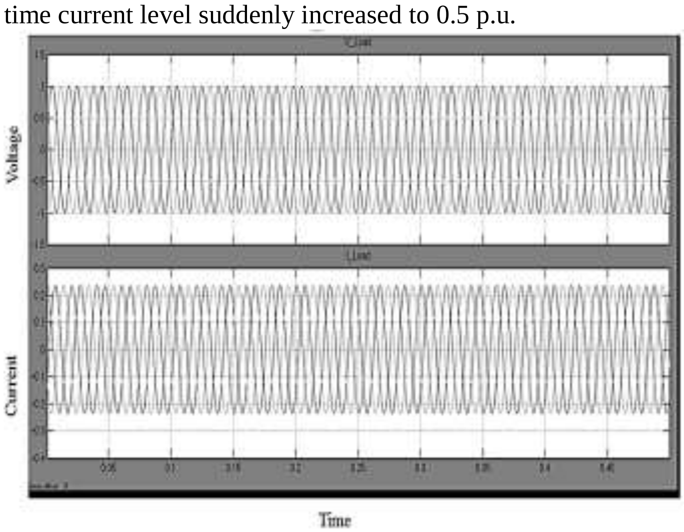

Fig. 8: Voltage and current waveform in load side

In Fig.8 describes on load side the voltage and current are trying to compensate by injecting the reactive power through STATCOM. The constant voltage and current in load side is maintained by STATCOM.

Source side	Load side	Controller
0.92	0.7	PI
0.98	0.7	Fuzzy logic
0.99	0.7	ANN

Table 2: Power Factor Value

On using PI controller [1] power factor on source side is 0.9 and load side is 0.7. The source side and load side power factor are achieved by the ANN controller. By comparing the PI controller with ANN, there is an improvement in source side power factor in this work.

V. CONCLUSION

With large penetration of small distributed-generation units there is a desire for the extensive use of dynamic reactive power sources to facilitate fast voltage recovery. STATCOM is used as a VAR compensator and a systematic methodology has been developed for fast voltage recovery at the DG bus in an economical manner. The STATCOM controller parameter is selected for tuning after a detailed analysis of the dynamic model. By means of this methodology, STATCOM provides the compensation by injecting or absorbing reactive current at the time of uncertainties within the less response time and also provides the better contribution. Also this methodology reduces the number as well as the rating of STATCOMs through the tuning of control parameter. It is clear that the developed methodology provides an effective contribution in the case of faster voltage recovery. Simulation results prove the effectiveness of the proposed system for a DG-based industrial system. In this paper, the fast voltage recovery and reactive power compensate can be achieved by ANN controller.

REFERENCE

[1] Aziz.T, Hossain.M.J,Saha, T.K "VAR planning with tuning of STATCOM in a DG integrated industrial system ", IEEE trans. power system,vol.28,no.2,April-2013.
[2] Marta Molinas,Jon Are Suul, Tore Undeland "LVRT of wind farms with cage generators: STATCOM Versus SVC", IEEE Trans on Power electronics, vol.23, no.3, may-2008
[3] Aziz.T,Hossain.M.J ,Saha.T.K "Stability evaluation of distributed generator integrated system with index based placement of STATCOM" IEEE Conferences on Innovative smart grid technologies Asia , 2011.
[4] Asha Vijayan,Padma.S " Maintaining Voltage Stability in Power System using FACTS Devices", International Journal of Engineering Science Invention, Vol.2,Issue 2,Feb-2013
[5] Bindeshwar Singh,Sharma.N.K,Verma.K.S "A Status review of Incorporation of FACTS Controllers in Multi-Machine Power Systems for Enhancement of Damping of Power System and Voltage stability" International journal of Engineering Science and Technology Vol,2010.
[6] Del Valle.Y, Hernandez.J.C,Venayagamoorthy.G.K "Multiple STATCOM allocation and sizing using particle swarm optimization ",IEEE Conferences on power system conference and Exposition, 2006.
[7] Seraj Ahamad and Aziz Ahmed " Optimal Location of STATCOM Using PSO In IEEE 30 bus system",International journal of advance Research in Science and Engineering,Vol.no.2,Issue No.5,May 2013.
[8] Ramya, N.B.Rajesh and B.Karthika "Location and sizing of Multiple DG units for Voltage stability and loadability Enhancement in Radial Distribution Systems using PSO", International Journal of applied engineering research, 2014.
[9] S.Jadid, A.Salami " Application of Dynamic Programming method for Reactive Power Planning" IEEE Conferences,2009
[10] Anju Gupta,P.R sharma "Design and simulation of fuzzy logic controller for DSATCOM in power system" International journal of engineering science and technology vol.3,no.10 October 2011
[11] Ravi Teja Palle "Fuzzy logic control of shunt connected compensator for power quality connected grid system" Journal of engineering research and application, vol.3, issue 6, nov-dec 2013.