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POWER QUALITY IMPROVEMENT OF UNBALANCED DISTRIBUTION SYSTEM USING LMBNN BASED D-STATCOM

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ABSTRACT

In this paper to address well known power quality issues such as voltage swell, voltage sag of unbalanced distribution system, a Levenberg-Marquardt Back propagation(LMBNN) based D-STATCOM is proposed. The performance of proposed an ANN based D-STATCOM is tested on 13-bus IEEE test feeder, a D-STATCOM is placed at bus no-632.The performance of proposed ANN based D-STATCOM is compared to D- STATCOM with PI control mechanism using MATLAB-simulink.

KEYWORDS: MATLAB-simulink, D-STATCOM, LMBNN.

INTRODUCTION

Now a day's power quality is a more serious problem for consumers and power companies. The power quality issues such as voltage swell and voltage sag leads to economic impact on consumer utility sectors like induction furnaces and process control of bulk manufactures.[1-4] An Electrical distribution system is a connection between utility sector and Power Company, to provide quality of supply to consumer by maintains good voltage profile at consumer premises.[5]

Causes of Power quality problems in Electrical distribution system[6]

- Sag and swell, which varies from 10% to 90% of the rated voltage.
- Harmonic distortion in distribution system due to harmonic currents.
- Due to lower power factor causes heating of electrical equipment, results heating losses.
- It also causes vibration and noise in machines and malfunction of the sensitive equipment.
- Due to unbalanced voltages.

There are two methods to resolve power quality problems. The first approach is from source side and second approach is from load side to diminish well known power quality problems such as voltage swell and voltage sag.

If there is sudden increase in the load then the voltage in the line decreases rapidly due to the decrease in the terminal voltage at the receiving end or the utility side. This sudden change in the terminal voltage appears as sag.

If there is a sudden decrease in the load then the voltage in the line increases rapidly due to the increase in the terminal voltage at the receiving end or the utility side. This sudden change in the utility side terminal voltage appears as voltage swell in the line.[8]

There are different ways to enhance power quality problems in transmission and distribution systems. D-STATCOM is a suitable custom power device to address the power quality issues of an unbalanced distribution system and efficient device to resolve power quality issues, D-STATCOM consisting of a Voltage Source Converter (VSC) and a shunted DC link capacitor.[9-10] A D-STATCOM is reactive source, generating and absorbing reactive power. In this paper a 13-bus unbalanced distribution system is considered to address power quality problem and a D-STATCOM is connected at bus number 632.

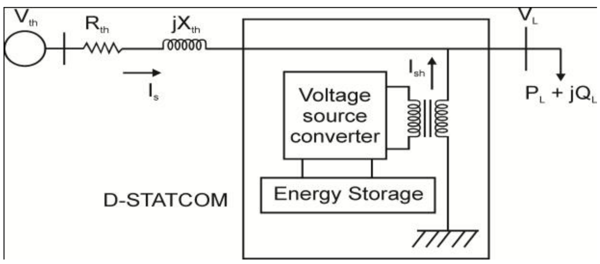

Fig. 1: Block diagram of D-STATCOM.

This paper is organized as follows the D-STATCOM with PI control mechanism is discussed in section II. The D-STATCOM with ANN control mechanism is discussed in section III. In section IV simulation results are presented where, the performance of D-STATCOM with ANN control technique is compared to PI control mechanism. Finally conclusions are given in section V.

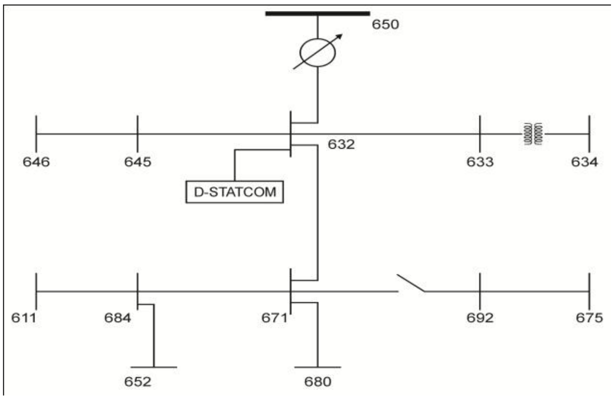

Fig. 2: IEEE-13 bus unbalanced distribution system with D-STATCOM.

Conventional Control of D-Statcom

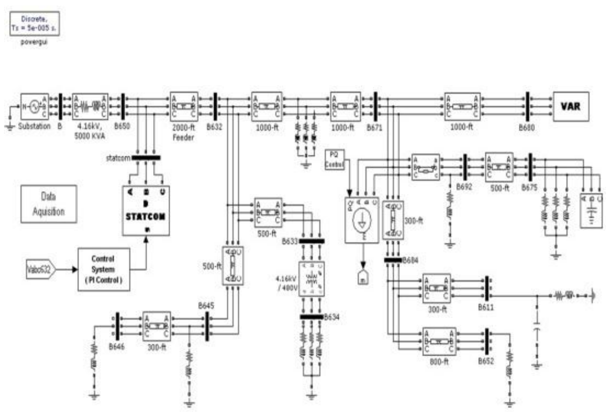

Fig. 3: 13-Bus unbalanced Distribution System with D-STATCOM with PI Control Mechanism.

D-Statcom with Ann Control Mechanism

The ANN is a mathematical model composed of simple elements operating in parallel. The ANN function is nothing but connection between the elements, by altering the weights we can train a neural network for particular task.[17]

In Fig-4 shows an artificial neuron with one input and bias P_i is the scalar input transmitted through connections that multiply with scalar weight W_i to get product of W_i P_i . The summation of all weight becomes $\sum W_i P_i$ and additionally adding bias input b.The result is the arrangement of transfer function Fig-4, which produces the output .We can get desired output by adjusting weights and bias of the NN.[17]

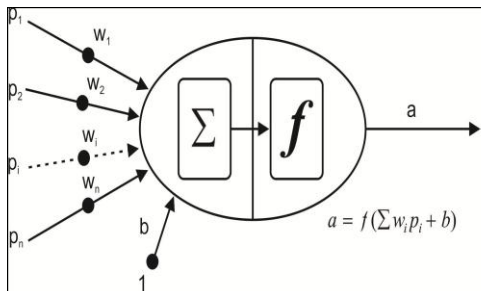

Fig. 4: An artificial neuron with one input and biases.

Neural networks consisting of different types of architectures .The commonly used ANN model are multi-layer perception (MLP) and radial bias function (RBF) networks.

A MLP consisting of input layer, hidden layer and output layer. In Fig-5 suffix-i indicates a neuron. Numbers of input neurons are summed at summer and g is an activation function.

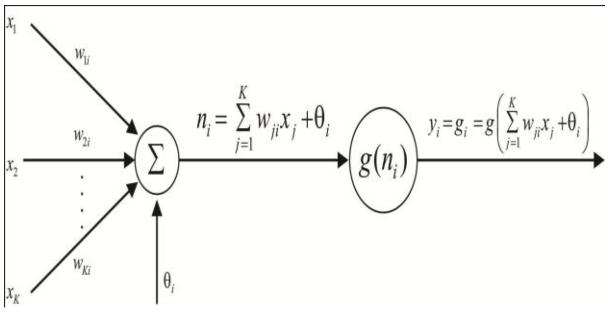

Fig 2: Single node in a Multi-Layer Perceptron network.

Output of the ith neuron

$U_i = g_i = g[\sum_{j=1}^{k} w_{ji} \; x_j + \theta_j]$

MLP is formed by connecting more number of nodes in parallel.

The output (Y_i)of the MLP layer becomes a nonlinear model can be trained for any nonlinear parameterization by adjusting weights and bias factors of the system. In the implementation of ANN model for system parameterization ANN model is trained these algorithms are called learning (or) training algorithms. The most popular algorithms are Back Propagation Algorithm (BPA) and Levenberg-Marquardt algorithm. Levenberg-Marquardt is most efficient algorithm compared to BPA.[17]

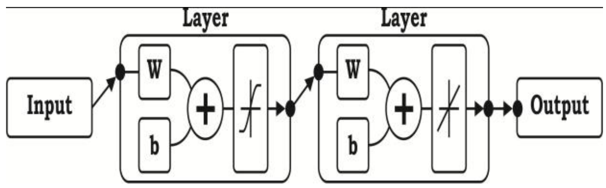

Fig. 3: Two layer feed-forward network.

Procedure for training algorithms for MLP networks

1. The mathematical structure of NN is first defined and activation functions also chosen and network parameters, weights and biases are initialized.[17]
2. The ANN network parameters such as number of iterations, error goal are defined.
3. The training algorithm is called
4. After NN is trained, the results are tested by simulating the output of NN with measured input data. This is compared with measured output, with the knowledge of independent data and final execution will be carried out.

Neural Network Training Algorithm

In ANN there are three popular learning algorithms namely Back Propagation Algorithm (BPA), Quasi-newton (trainbfg) and Levenberg-Marquardt (trainlm), the output of the network compared to desired reference target to minimize the error by adjusting the weights and biases.[17] This is the only algorithm which gives best regression accuracy. In this method global error E is defined as.[17]

$$E=\frac{1}{2}\sum(tj-yi)^2$$

Where t_j is targeted output and y_i is the actual output.

Levenberg-Marquardt ANN Algorithm

The Levenberg-Marquardt (trainlm) algorithm is a superior training algorithm compared to other training methods because of the fast convergence and high speed.This algorithm is a combination of steepest descent method and the Gauss-Newton algorithem.This algorithm is designed to achieve second order training speed without considering Hessain matrix [H].[17,18]

The Hessain matrix [H] can be written as $H=J^T.J(J = Jacobian\ matrix)$

Gradient can be calculated as $g=J^T.e$, where $(J = J = Jacobian\ matrix)$of network errorwith respect to weights and biases and e is a network error.[17]

Hessain matrix [H] approximation is used while training Levenberg-Marquardt Algorithm.[17,18]

$$\Delta W = [J^T.J+]\ J^T.e$$

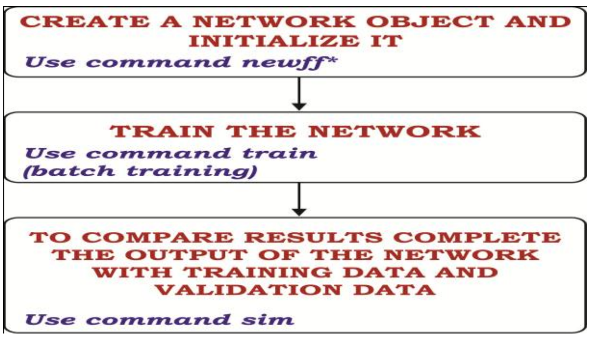

Fig. 4: Flow chart for design of LMBNN based D-STATCOM.

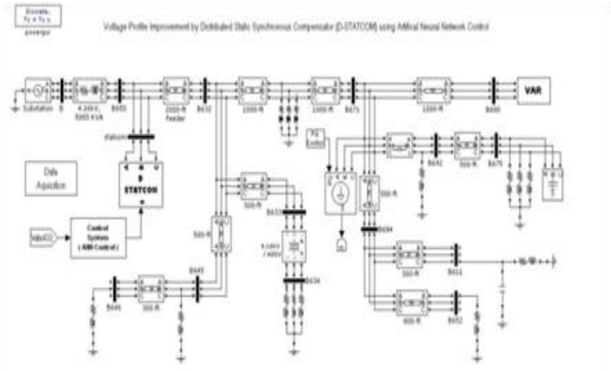

Fig. 5: 13-Bus unbalanced Distribution System with D-STATCOM with ANN Control Mechanism.

SIMULATION RESULTS

In this work a D-STATCOM with ANN control mechanism have been proposed to improve power quality (voltage swell, voltage sag) of 13-bus IEEE distribution system. Simulations are performed using MATLAB SIMULINK.The performance of proposed D-STATCOM with ANN control technique is compared to D-STATCOM with PI control technique.

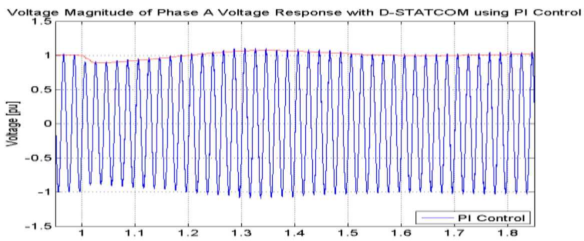

Fig. 6: Illustrates mitigation of voltage sag of phase-A from source side using D-STATCOM with PI control mechanism.

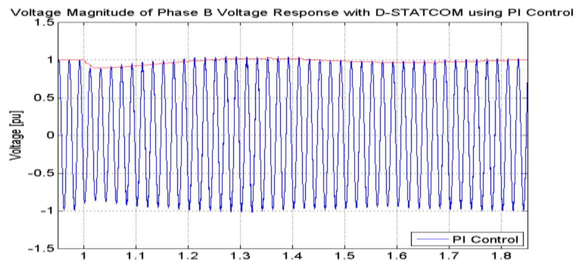

Fig. 7: Illustrates mitigation of voltage sag of phase-B from source side using D-STATCOM with PI control mechanism.

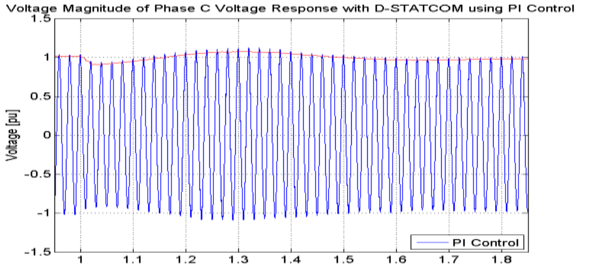

Fig. 8: Illustrates mitigation of voltage sag of phase-C from source side using D-STATCOM with PI control mechanism.

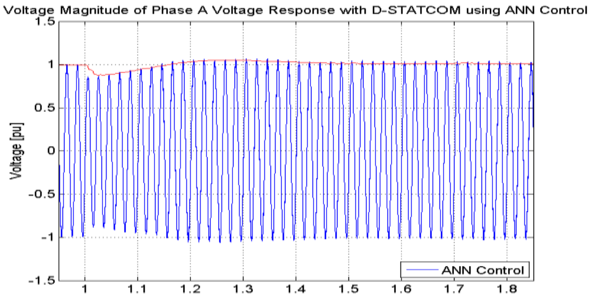

Fig. 9: Illustrates mitigation of voltage sag of phase-A from source side using D-STATCOM with ANN control mechanism.

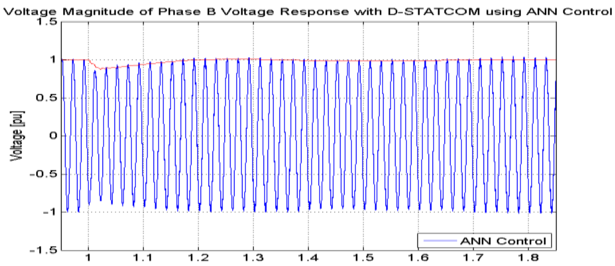

Fig. 10: Illustrates mitigation of voltage sag of phase-B from source side using D-STATCOM with ANN control mechanism.

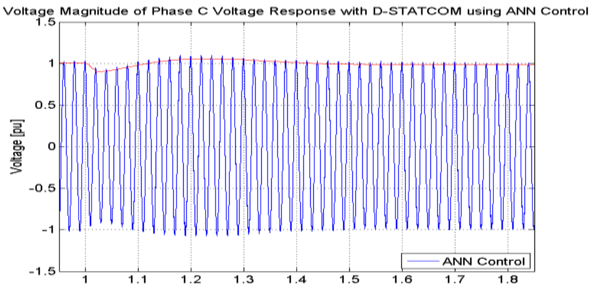

Fig. 11: Illustrates mitigation of voltage sag of phase-C from source side using D-STATCOM with ANN control mechanism.

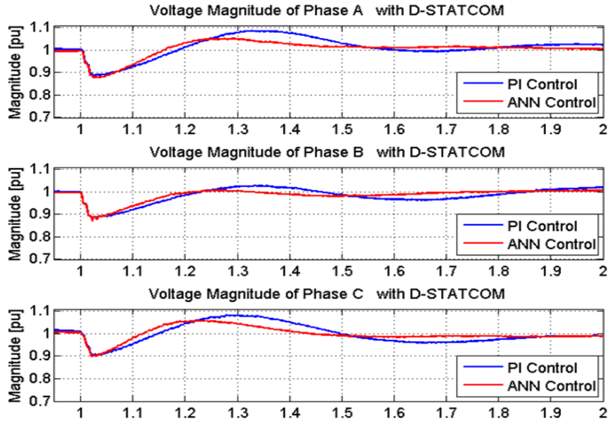

Fig. 12: Illustrates mitigation of voltage sag of phase A, B, C from source side using D-STATCOM with PI & ANN control.

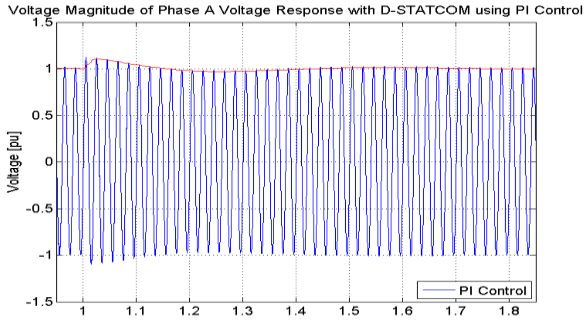

Fig. 13: Illustrates mitigation of voltage swell of phase-A from load side using D-STATCOM with PI control mechanism.

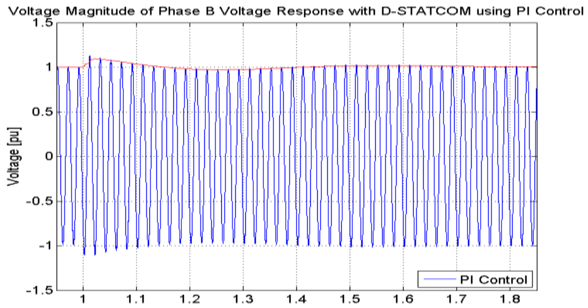

Fig. 14: Illustrates mitigation of voltage swell of phase-B from load side using D-STATCOM with PI control mechanism.

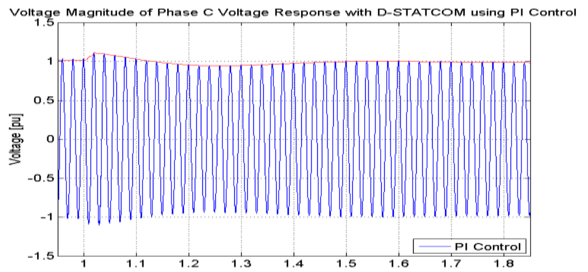

Fig. 15: Illustrates mitigation of voltage swell of phase-C from load side using D-STATCOM with PI control mechanism.

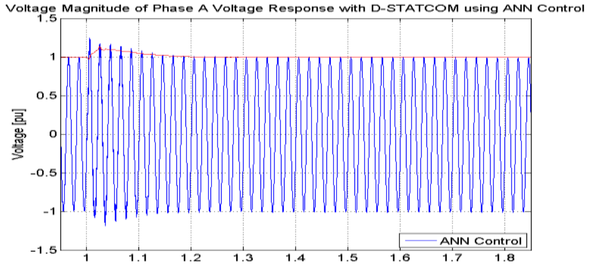

Fig. 16: Illustrates mitigation of voltage swell of phase-A from load side using D-STATCOM with ANN control mechanism.

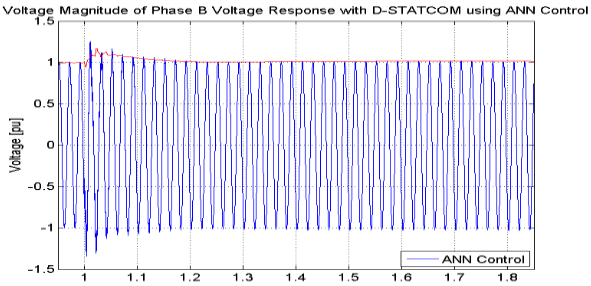

Fig. 18: Illustrates mitigation of voltage swell of phase-C from load side using D-STATCOM with ANN control mechanism.

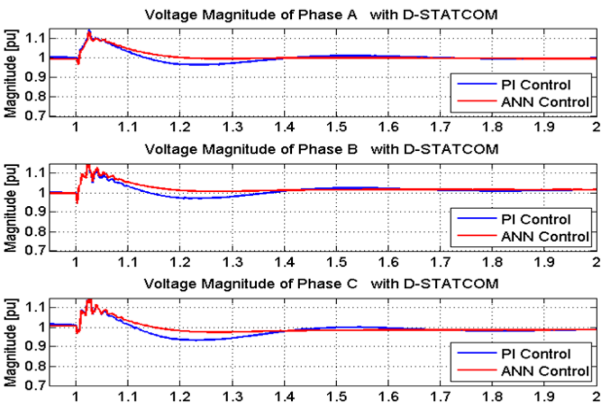

Fig. 19: Illustrates mitigation of voltage swell of phase A, B, C from load side using D-STATCOM with PI & ANN control.

CONCLUSION

In this paper for enhancement of power quality of distribution system a 13- bus system is considered. An ANN control based D-STATCOM is introduced at bus number-632 of 13-bus IEEE test feeder system. The performance of proposed method is compared with PI based D-STATCOM. Simulation results revealed that the proposed intelligent control methodology based D-STATCOM can tackle power quality issues such as voltage sag, voltage swell at all bus considerably. An ANN based D-STATCOM is quite capable of suppressing voltage swell and voltage sag compared to PI based D-STATCOM.

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