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Neural Network Based Distributed Powerflow Controller For Mitigating Voltage Sag And Swell In A Transmission System

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***Abstract**: Reactive power variations, due to non linear loads, are the cause for most of the power quality issues. Insufficient reactive power causes Voltage Sag, as well as excess reactive power causes the Swell. To control the voltage to a desired value, regulation of reactive power is required. There is an existing approach known as UPFC for the improvement of voltage profile. In this paper a novel intelligent control scheme is proposed for the improvement of voltage profile of a 4 bus system.For proper control of reactive power a new D-FACTS device, DPFC is used. First, Conventional PI controller is used for the controlling action of DPFC connected to a load bus. To improve the efficiency of controlling action of DPFC, Neuro controller is used. The addition of Neuro controller with the DPFC improves the Voltage Profile in a better way. The entire circuit is simulated using MATLAB/SIMULINK.*

***Keywords**: DPFC, PI Controller, Power Quality, Neuro Controller, Voltage Sag, Voltage Swell.*

I. INTRODUCTION

Electrical power is perhaps the most essential raw material used by commerce and industry today. It is an unusual commodity because it is required as a continuous flow. For ‘Just in Time’ (JIT) philosophy to be successful it is necessary to have good control of the component specification. The most obvious power defects are complete interruption (which may last from a few seconds to several hours) and voltage dips or sags where the voltage drops to a lower value for a short duration. Naturally, long power interruptions are a problem for all users, but many operations are very sensitive to even very short interruptions.Voltage control in an electrical power system is important for proper operation for electrical power equipment to prevent damage such as overheating of generators and motors, to reduce transmission losses and to maintain the ability of the system to withstand and prevent voltage collapse.Ingeneral terms, decreasing reactive power cause voltage to fall while increasing it cause voltage to rise [13].While the majority of voltage dips and interruptions originate in the transmission and distribution system [12]. A voltage collapse occurs when the system try to serve muchmore load than the voltage can support [13]. Due to the use of the different types of sensitive electronic equipments, PQ issues have drawn substantial attention from both utilities and users [3].

In this paper, a distributed power flow controller is introduced to mitigate voltage waveform deviation and improve power quality within seconds. The DPFC structure is derived from the UPFC structure that is includedone shunt converter and several small independent series converters as shown in Fig.1 [7].

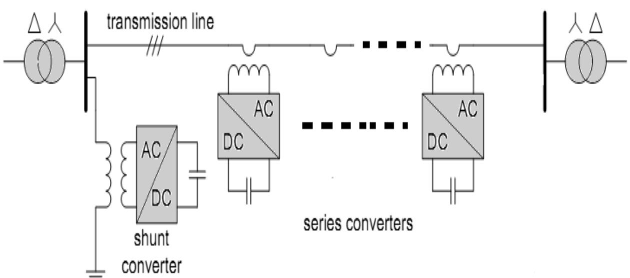

Fig. 1: The DPFC Structure

A DPFC is connected to a 4 bus transmission system as shown in Fig. 2. The DPFC consists of one shunt andseveral series-connected converters. The shunt converter is similar as a STATCOM, while the series converteremploys the D-FACTS concept, which is to use multiple single-phase converters instead of one large rated converter [1]. Within the

DPFC, there is a common connection between theac terminals of the shunt and the series converters, which is the transmission line. Therefore, it is possible to exchange the active power through the ac terminals of the converters.

DPFC consists of three types of controllers; they are central controller, shunt control, and series control.The central control generates the reference signals for both the shunt and series converters of the DPFC[1].

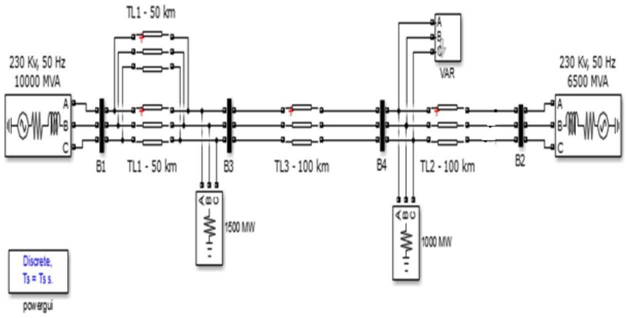

Fig. 2 Simulated IEEE Four Bus System

All the reference signals generated by the central control are at the fundamental frequency. Each series converter has its own series control. The controller is used to maintain the capacitor dc voltage of its own converter and to generate series voltage at the fundamental frequency that is prescribed by the central control. The shunt converter's fundamental frequency control aims to inject a controllable reactive current to grid and to keep the capacitor dc voltage at a constant level [1].

II. CONVENTIONAL CONTROL OF DPFC

This paper proposed a Conventional PI controller for the improvement of the performance of the DPFC connected to a 4 bus system.

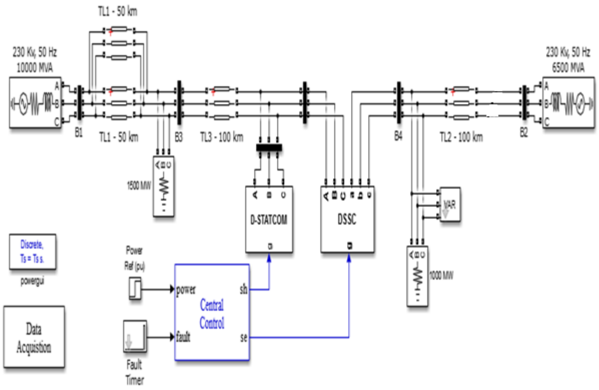

Fig.3 Distributed Power Flow Controller with PI Contol

The performance with DPFC and without DPFC is observed and it is found that with the conventional controller the voltage of the bus is not reached to nominal value after clearance of sag and swells.

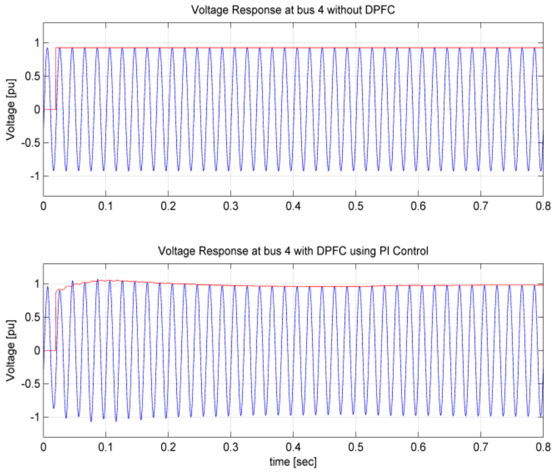

Fig. 4 Voltage response of DPFC with PI and without PI

III. ANN CONTROL OF DPFC

Neural networks represent a class of very powerful, general-purpose tools that have been successfully applied to prediction, classification and clustering problems. The popularity of neural networks is based on their remarkable versatility, abilities to handle both binary and continuous data, and to produce good results in complex domains. When the output is continuous, the network can address predictionproblems, but when the output is binary, the network works as a classifier.

An artificial neural network consists of a number of very simple and highly interconnected processors, also called neurons, which are analogous to the biological neurons in the brain. The neurons are connected by weighted links passing signals from one neuron to another. Each neuron receives a number of input signals through its connections; however, it never produces more than a single output signal. The output signal is transmitted through the neuron's outgoing connection[13].

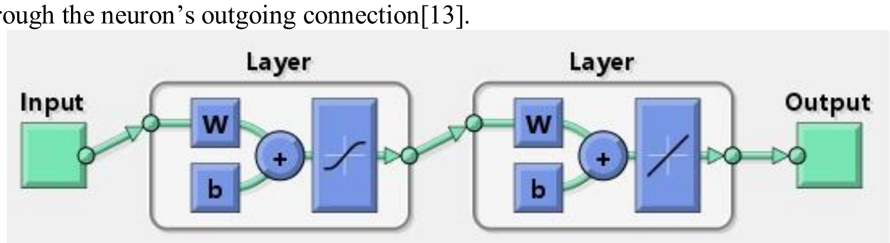

Fig.5 Architecture of Artificial Neural Network

A typical ANN is made up of a hierarchy of layers, and the neurons in the networks are arranged along these layers. The neurons connectedto the external environment form input and output layers. The weights are modified to bring the network input/output behavior into line with that of the environment.Increasing the complexity of an ANN, and thus its computational capacity, requires the addition of more hidden layers, and more neurons per layer.

Each neuron is an elementary information-processing unit. It has a means of computing its activation level given the inputs and numerical weights. To build an artificial neural network, we must decide first how many neurons are to be used and how the neurons are to be connected to form a network. In other words, we must first choose the network architecture. Then we decide which learning algorithm to use. And finally we train the neural network, that is,we initialize the weights of the network and update the weights from a set of training examples[13].

The neuron computes the weighted sum of the input signals and comparesthe result with a threshold value,θ. If the net input is less than the threshold, theneuron output is -1. But if the net input is greater than or equal to thethreshold, the neuron becomes activated and its output attains a value +1.

The neuron uses the following transfer or activation function[13]

$$X_{k+1} = X_k – [J^TJ + \mu I]^{-1}J^Te$$

Where J is the Jacobian matrix that contains first derivatives of the network errors with respect to the weights and biases and e is the vector of network errors. J can be computed through back propagation technique.

This function uses the Jacobian for calculations, which assumes that performance is a mean or sum of squared errors. Therefore, networks trained with this function must use either the mse orsse performance function.

Levenburgmarquardtalgorithm can train any network as long as its weight, net input, and transfer functions have derivative functions.

Training stops when any of these conditions occurs:

- The maximum number of epochs (repetitions) is reached.
- The maximum amount of time is exceeded.
- Performance is minimized to the goal.
- The performance gradient falls below min_grad.
- µ exceeds µ_max.
- Validation performance has increased more than max_fail times since the last time it decreased (when using validation).

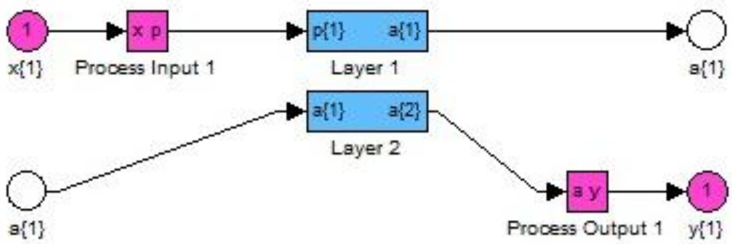

Fig.6: Neural Network Control

IV. RESULTS

In this paper a comparison is made on the performance of DPFC with PI, Fuzzy and Neural Network Controlling techniques for the improvement of Power Quality issues, voltage sag and swell. The proposed controllers are evaluated by computer simulation in MATLAB/SIMULINK. The proposed intelligent controllers improved the power quality of the transmission system at load bus. The results are taken on 2% tolerance base.

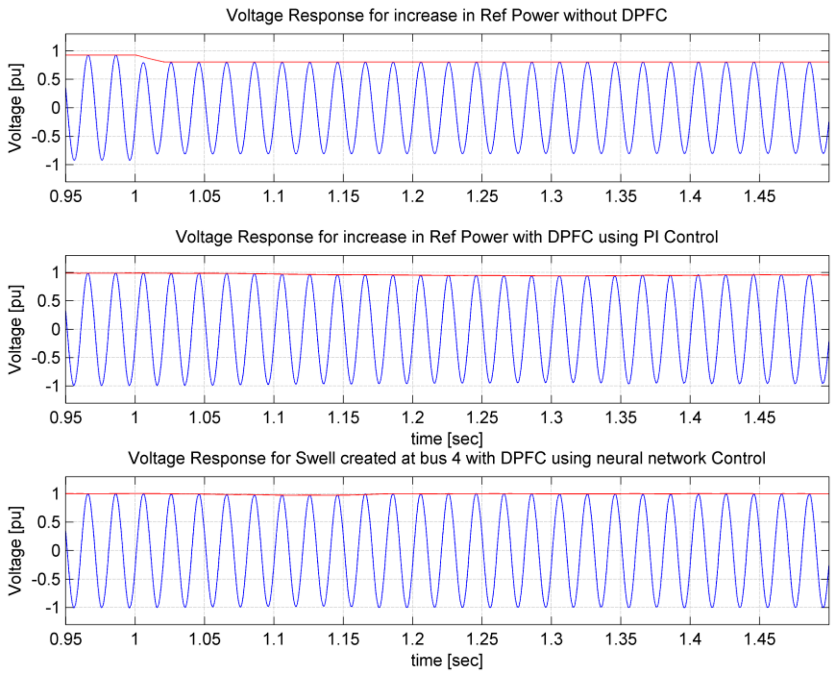

Fig. 7: Voltage Response at load bus with ANN controller

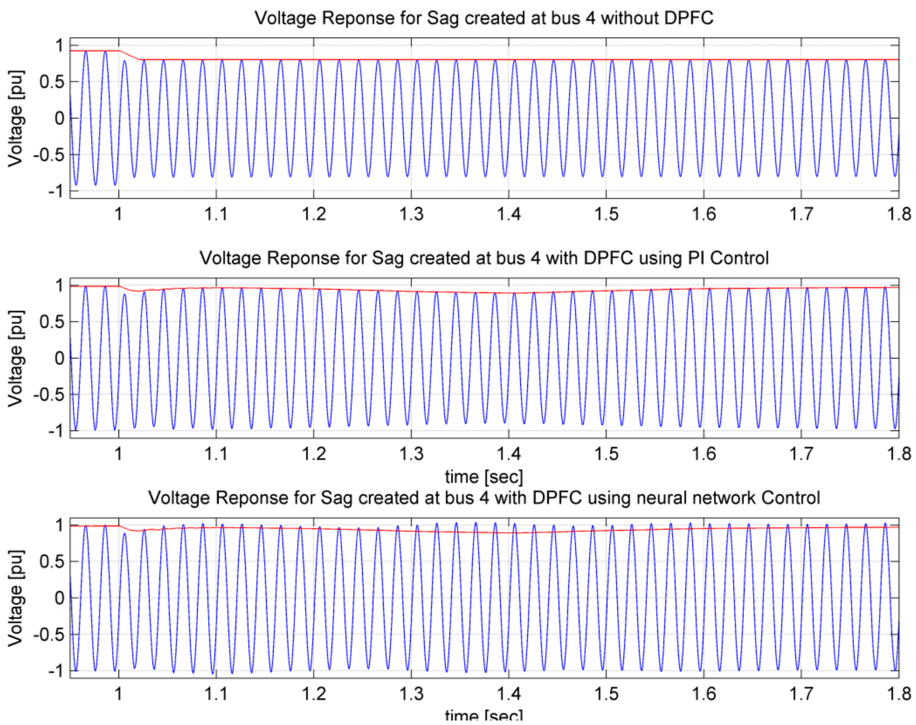

Fig. 8: Voltage Response at load bus for sag clearance with ANN controller

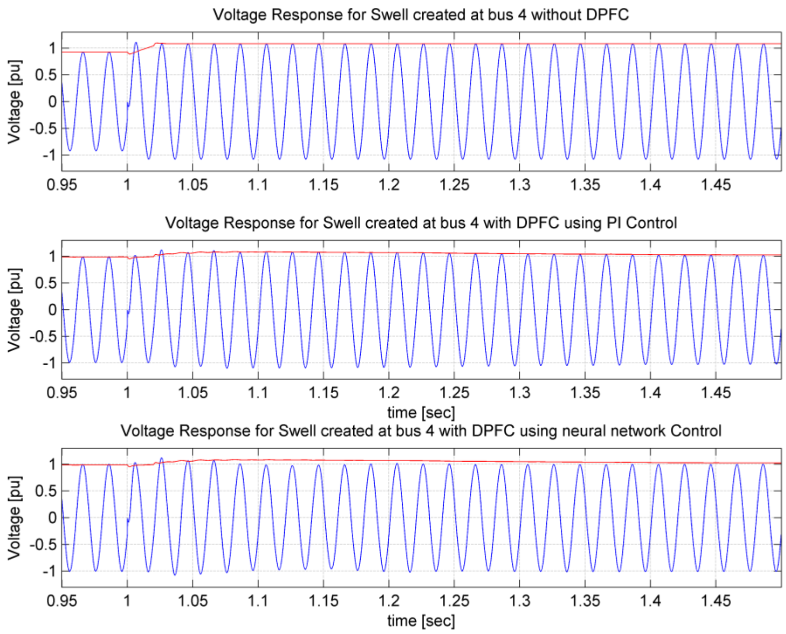

Fig. 9: Voltage Response at load bus for swell clearance with ANN controller

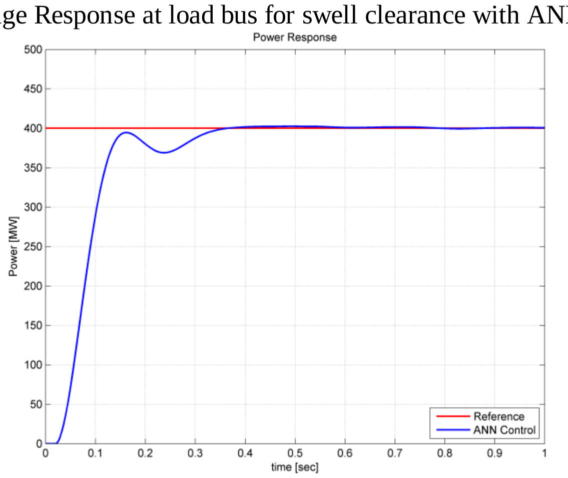

Fig. 10:Power Response at load bus

V. CONCLUSION

To improve the power quality of the transmission system there are many methods available. This paper has presented a novel intelligent control technique for DPFC to improve the power quality. Observations made with the Conventional PI controller and the proposed neuro controlled DPFC. The improvement in voltage profile is at a faster rate with the Artificial Neural Network controlling technique. The entire system is simulated in MATLAB/SIMULINK. Thelimitations of the conventional control are rectified by the proposed ANN controller. The experimental results of conventional and intelligent control techniques are presented with different situations like voltage sag, voltage swell and reactive power with controllers and without controllers, at load bus. It is shown that the ANN Controlled DPFC has improved the voltage profile at a faster rate.

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