Controlling of DSTATCOM for Pulsed Load by using ANN

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Abstract— In power system, power quality problems mainly arise due to the pulsed loads, which cause the degradation of the entire system performance during very short period of time which cause the degradation of the entire system performance. This paper presents the application of DSTATCOM to reduce the impact of pulsed load on a bus voltage and thus keep it at desired level improve the power quality in a power system during and after pulsed loads Distribution Static Compensator (DSTATCOM) is a Voltage-source Inverter (VSI) based shunt compensation device which is generally used to solve power quality problems in distribution systems. The control strategy of the DSTATCOM plays an important role in maintaining the voltage at the point of common coupling, A novel adaptive control for the DSTATCOM based on artificial Neural Network (ANN) for pulsed load is proposed in this paper. To evaluate the performance of the DSTATCOM and the ANN adaptive controller, a power system is developed in the MATLAB/SIMULINK environment. The effectiveness of the DSTATCOM and the ANN controller is examined for pulsed loads of different magnitudes and durations.

Key words: ANN, Bus Voltage, DSTATCOM, Power Quality, Pulsed load, VSI

I. INTRODUCTION

Nowadays, the term power quality has becoming increasingly concerned by both electric utilities and end users of electrical power. The power quality problems are compensated in a distribution system by the Custom Power devices. These custom power devices are classified as the DSTATCOM (Distribution Static Compensator), DVR (Dynamic Voltage Restorer) and UPQC (Unified Power Quality Conditioner). The effectiveness of DSTATCOM depends upon the control algorithm used for generating the switching signals for the voltage source converter and value of interfacing inductors. In this Paper, the designed system will be applied to detect transient voltage in electrical power systems. The problem of power quality is detected by artificial neural network based BP algorithm. The power system is an integrated network, where the propulsion load, the distribution loads, sensor and other emergency loads and pulse loads (lathe machine, sudden switching loads, aircraft launcher in case of navy ship etc.) – all are part of the same electrical network. The main advantage of DSTATCOM is that, the current injection into the distribution bus can be regulated very efficiently by the sophisticated power electronics based control present in it. It can be used for canceling the effect of poor load power factor, for suppressing the effect of harmonic content in load currents, for regulating the voltage of distribution bus against sag/swell etc. and also for compensating the reactive power requirement of the load and so on. In this project, the application of DSTATCOM to regulate voltage at the point of common coupling (PCC) is presented.

II. LITERATURE SURVEY

In the Literature survey it reveals that high rating STATCOM operated under fundamental frequency switching, the principle of phase angle control (a) is generally adopted in control algorithm to compensate converter losses by active power drawn from AC system and also for power flows in or out of the VSC to indirectly control the magnitude of DC voltage with charging or discharging of DC bus capacitor enabling control of reactive power flow into the system. This aspect is well presented in [1-2].

Power Generation and Transmission is a complex process, requiring the working of many components of the power system in tandem to maximize the output. One of the main components to form a major part is the reactive power in the system. It is required to maintain the voltage to deliver the active power through the lines. Loads like motor loads and other loads require reactive power for their operation. To improve the performance of ac power systems, we need to manage this reactive power in an efficient way and this is known as reactive power compensation. There are two aspects to the problem of reactive power compensation: load compensation and voltage support. Load compensation consists of improvement in power factor, balancing of real power drawn from the supply, better voltage regulation, etc. of large fluctuating loads. Voltage support consists of reduction of voltage fluctuation at a given terminal of the transmission line. Two types of compensation can be used: series and shunt compensation. These modify the parameters of the system to give enhanced VAR compensation. [3-4]. Switching topologies such as PWM or power frequency switching depend upon the type of solid-state devices used in STATCOM. Primarily, fundamental frequency method of switching (pulsed one per line frequency cycle) and PWM techniques (pulsed multi times per half cycle) are widely accepted methods. The various aspects of PWM-VSC based STATCOM have been presented in [5] As GTO is well-proven solid-state device and commercially available with power-handling levels as that of the conventional thyristor,

GTO-VSC is the backbone of the high power rating STATCOMs [6] that are used extensively in high-voltage transmission system. The control system is the heart of state-of-the-art STATCOM controller for dynamic control of reactive power in electrical system. Based on the operational requirements, type of applications, system configuration and loss optimization, essential control parameters are controlled to obtain desired performance and many control methodologies in STATCOM power circuits have been presented in [7].

Among the loads, the effects of pulse loads are most detrimental for the power quality of power distribution system as they require a very high amount of energy for a very short period of time. For example In order to improve the survivability of a navy ship in battle conditions, a distribution static compensator (DSTATCOM) can be used to reduce the impact of pulse loads on the bus voltage and thus keep it at desired level. DSTATCOM is a voltage-source inverter (VSI) based shunt device generally used in distribution system to improve power quality.

The main advantage of DSTATCOM is that, the current injection into the distribution bus can be regulated very efficiently by the sophisticated power electronics based control present in it. Another advantage is that, it has multifarious applications, e.g. it can be used for canceling the effect of poor load power factor, for suppressing the effect of harmonic content in load currents, for regulating the voltage of distribution bus against sag/swell etc. and also for compensating the reactive power requirement of the load and so on.

III. DSTATCOM & ITS WORKING

The D-STATCOM is a three phase shunt connected reactive power compensation equipment, whose output can be varied so as to maintain control of specific parameters of the electric power system by the generation and /or absorption of the reactive power. The DSTATCOM consists of three phase GTO/IGBT voltage source inverter (VSI), a coupling transformer with a leakage reactance and DC capacitor. The DSTATCOM topologies can be classified based on of switching devices, use of transformers for isolation, use of transformers for neutral current compensation.

The D-STATCOM employs solid state power switching devices and provides rapid controllability of magnitude and the phase angle of the phase voltages.The DSTATCOM provides operating characteristics that of the rotating Synchronous compensator without the mechanical inertia. The D-STATCOM has an inverter to convert the DC link voltage Vdc on the capacitor to a voltage source of adjustable phase and magnitude. Therefore the DSTATCOM can be treated as a voltage controlled source or current controlled source.

When used in low-voltage distribution systems, the STATCOM is normally identified as Distribution STATCOM (D-STATCOM). Figure1 show the schematic diagram of the D-STATCOM. In its most basic form, the D-STATCOM configuration consist of a two level voltage source converter (VSC), a dc energy storage device, a coupling transformer connected in shunt with ac system, and associated control circuit. It operates in a similar way as the STATCOM device, with active power flow controlled by the angle between the AC system and VSC voltages and the reactive power flow controlled by the difference between the magnitudes of these voltages.

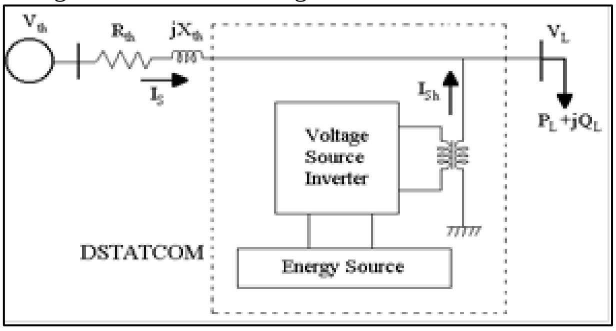

Fig. 1: Schematic Diagram of D-STATCOM

The capacitor is the main reactive power stored energy. It is connected in parallel with the DC source. The D- STATCOM controller continuously monitors the load voltages and currents and determines the amount of compensation required by the AC system for a variety of disturbances. The connection of the VSC is in shunt or parallel with the ac system and this type of connection can make DSTATCOM system to be used three different purposes that is:

1) Voltage regulation and compensation of reactive power;
2) Correction of power factor;
3) Elimination of current harmonics

A. *Benefits of DSTATCOM*

1) Tight voltage regulation.
2) Reduction in losses by maintaining power factor near unity at the load end.
3) Compensation of voltage sags, swells and transients.
4) Increased Transmission Capability
5) Reduced Transmission Losses
6) Improved Voltage Control
7) Rapid dynamic response

IV. FEED FORWARD NEURAL NETWORK WITH BACKPROPOGATION

One can differentiate between two basic types of networks, networks with feedback and those without it. In networks with feedback, the output values can be track back to the input values. However there are networks wherein for every input vector laid on the network, an output vector is calculated and this can be read from the output neurons. There is no feedback. Hence only a forward flow of information is present. Networks having this structure are called as feed forward networks. There are various nets that come under the feed forward type of nets. One of the most important types of feed forward network is the Back propagation network.

A. *Back Propagation Network (BPN)*

Back propagation is a systematic method for training multi-layer artificial neural networks. It has a mathematical foundation that is strong if not highly practical. It is multilayer forward network using extend gradient-descent based delta learning rule, commonly known as back propagation (of errors)rule. Back propagation provides a computationally efficient method for changing the weights in feed forward networks, with differentiable activation function units, to learn a training sets of input output examples.GE Hinton, Rumelhart & R.O.Williams first introduced BPN in 1986.Being a gradient descent method it minimizes the total squared error of the output computed by the net. The network is trained by supervised learning method. The aim of this network is to train the net to achieve a balance between the ability to respond correctly to the input patterns that are used for training and the ability to provide good responses to the input that are similar.

Multiple layer perceptions have been applied successfully to solve some difficult diverse problems by training them in a supervised manner with a highly popular algorithm known as the error back-propagation algorithm. This algorithm is based on the error-correction learning rule.

It may be viewed as a generalization of an equally popular adaptive filtering algorithm-the least mean square (LMS) algorithm.

Error back-propagation learning consists of two passes through the different layers of the network: a forward pass and a backward pass. In the forward pass, an input vector is applied to the nodes of the network, and its effect propagates through the network layer by layer. Finally, a set of outputs is produced as the actual response of the network. During the forward pass the weights of the networks are all fixed. During the backward pass, the weights are all adjusted in accordance with an error correction rule. The actual response of the network is subtracted from a desired response to produce an error signal. This error signal is then propagated backward through the network, against the direction of synaptic connections. The weights are adjusted to make the actual response of the network move closer to the desired response.

A multilayer perception has three distinctive characteristics:

1) The model of each neuron in the network includes a nonlinear activation function. The sigmoid function is commonly used which is defined by the logistic function:

$$y = \frac{1}{1+\exp(-x)} \quad (1)$$

Another commonly used function is hyperbolic tangent.

$$y = \frac{1-\exp(-x)}{1+\exp(-x)} \quad (2)$$

The presence of nonlinearities is important because otherwise the input- output relation of the network could be reduced to that of single layer perception.

2) The network contains one or more layers of hidden neurons that are not part of the input or output of the network. These hidden neurons enable the network to learn complex tasks.
3) The network exhibits a high degree of connectivity. A change in the connectivity of the network requires a change in the population of their weights.

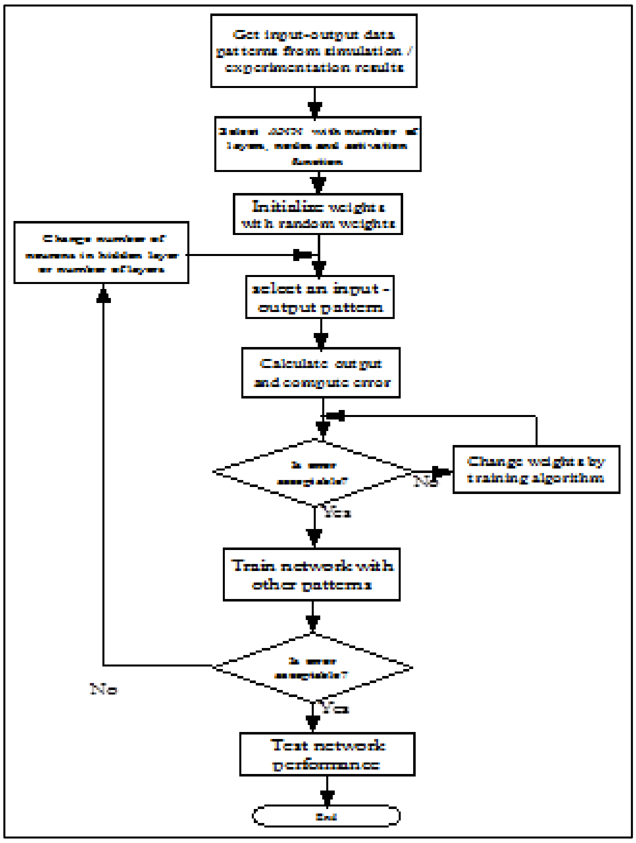

Fig. 2: Flow chart for training a feed forward back propagation type neural network for implementing the ANN-based controller

V. TEST AND RESULTS

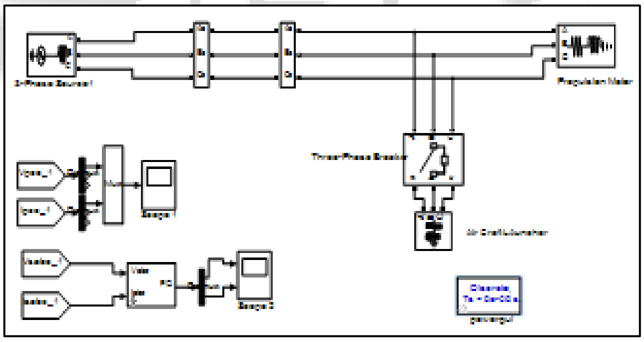

Fig. 3: Simulation Model of Uncompensated network

A simple transmission system has been model and the response of this system for different loading condition is observed below. Our main aim is to improve the power factor so that the power carrying capacity is enhanced in the transmission system .To improve the power factor we should reduce the reactive power flow in the system and bring the current almost in phase with voltage .In this uncompensated system we can see from the model response that the current is not in phase with voltage, reactive power is more in the system. And when we increase or decrease the load connected to the transmission line voltage and current profile becomes vast.

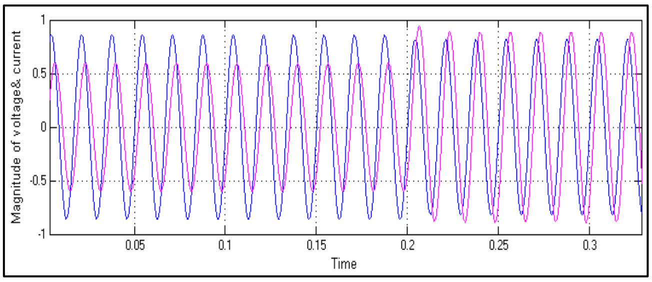

Fig. 4: Phase Voltage and Current Waveform for Uncompensated System

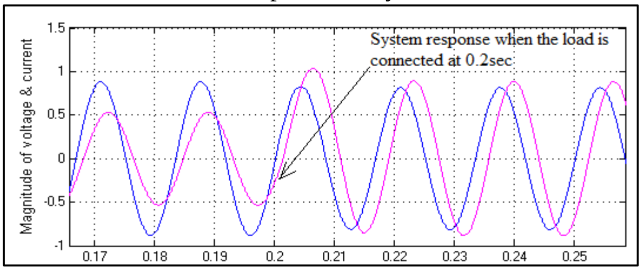

Fig. 5: Phase Voltage and Current Waveform for Uncompensated System when load is connected

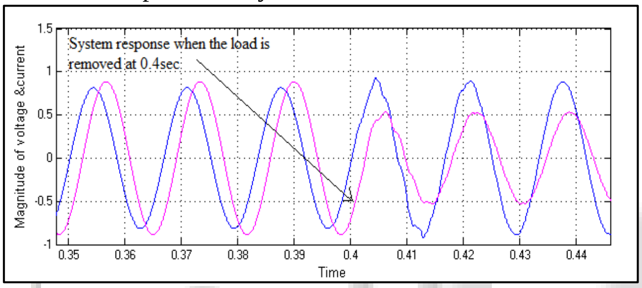

Fig. 6: Phase Voltage and Current Waveform for Uncompensated System when the load is removed

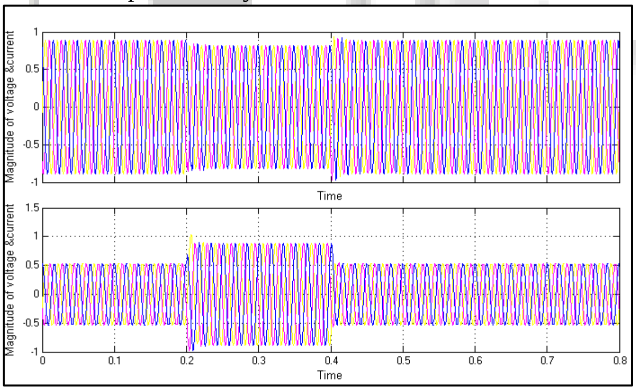

Fig. 7: 3-Phase Voltage and Current Waveform for Uncompensated System

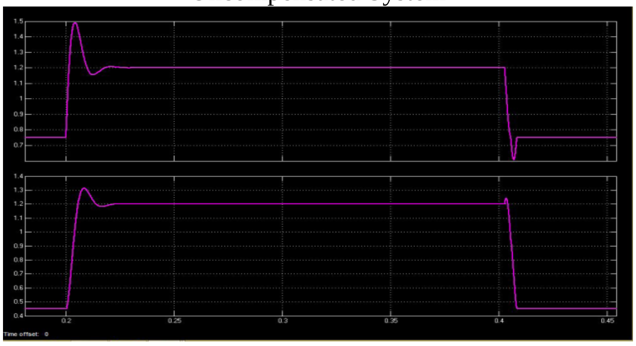

Fig. 8: Active and Reactive Power flow in uncompensated system

When a heavy inductive load in the transmission line is connected and after sometime suddenly disconnected there is a fluctuation occurs in the voltage and current profile. This voltage fluctuation causes lot of damage to the domestic and industrial equipment. Also in order to improve the power factor which in turn increases the power carrying capacity of the transmission system. We have to use a compensation technique in transmission system

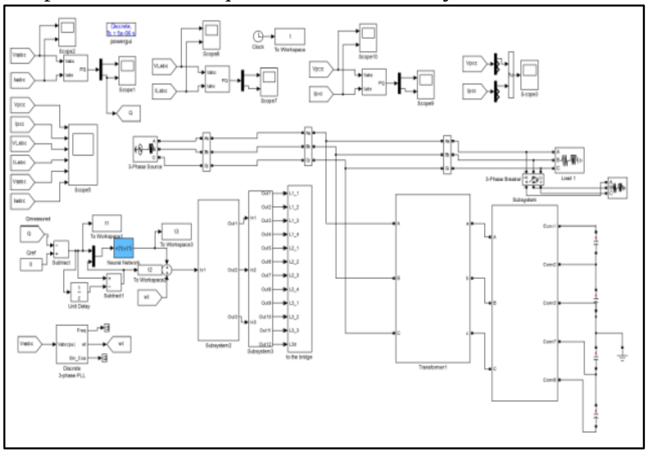

Fig: 9: Simulation Model of DSTATCOM based compensated system using ANN

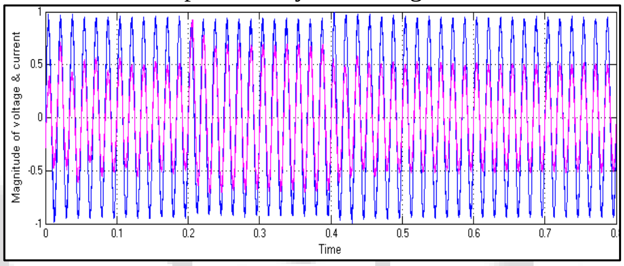

Fig. 10: 1-phase current and voltage waveform for DSTATCOM using ANN

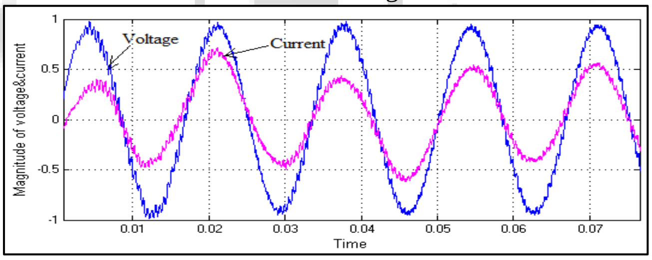

Fig. 11: Phase Current and Voltage waveform when the DSTATCOM is ON

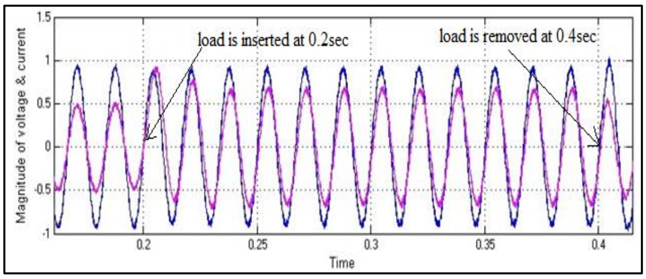

Fig. 12: 1 Phase Current and Voltage waveform when Load is Varied in the system

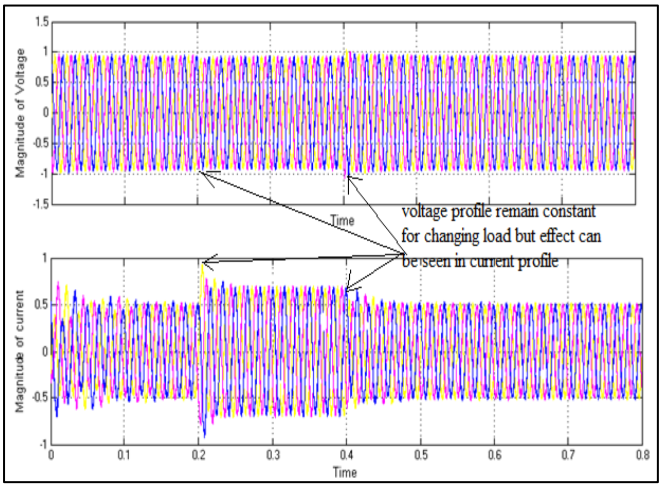

Fig. 13: 3-phase voltage and current waveform for DSTATCOM using ANN

Using ANN Initially when the DSTATCOM is on, it take around 0.02sec to bring voltage and current in phase i.e. Unity power factor. Now when suddenly load2 is switch on or connected to the transmission system voltage sag is created but the DSTATCOM supply the required amount of voltage to maintain the voltage profile. This affect the voltage and current phase difference .But it takes 0.03 sec to maintain zero phase difference between voltage and current. Similarly when the load 2 is suddenly disconnected from the supply voltage swell occurs. Here DSTATCOM absorbs the required amount of voltage to maintain the voltage profile and reduce the fluctuation in voltage. This also affect the voltage and current phase difference which is corrected by DSTATCOM which takes approx. 0.02sec to get a zero phase difference.

So we can conclude that the response time of DSTATCOM use in this system is around approx. 0.02sec to 0.04 sec i.e. (20 milliseconds to 40 milliseconds)

VI. Conclusion

A three phase VSC based DSTATCOM has been implemented for compensation of pulsed loads using BPT control algorithm to verify its effectiveness. The proposed algorithm has been used for extraction of reference source currents to generate the switching pulses for device of VSC of DSTATCOM. From this study, it is concluded that DSTATCOM and its control algorithm have been found suitable for compensation of pulsed loads. ANN based DSTATCOM provides faster dynamic response and gives accurate result and thus provides better reactive power compensation to improve power factor for improving various power quality problems.

References

[1] V. Siva Prasad, Syed Altaf Hussain, V. Pandurangadu, K. PalaniKumar, " Modelling and Analysis of spur gear for Sugarcane Juice Machine under Static Load Condition by Using FEA", July-Aug 2012,International Journal of Modern Engineering Research, Vol- 2/4, pp-2862-2866.

[2] Anju Tiwari, Prof. Minal Tomar ”An Extensive Literature Review on Power Quality Improvement using DSTATCOM” International Journal of Emerging Technology and Advanced Engineering, Volume 4, Issue 5, May 2014)

[3] Nitus .V & S. Chatratana “STATCOM Analysis and Controller Design for Power System Voltage Regulation” IEEE Tran “Transmission & Distribution Conference” China-2005

[4] K.L.Sireesha, K.Bhushana Kumar “Power Quality Improvement in Distribution System Using D-STATCOM” IJEAR Vol. 4, Issue Spl-1, Jan - June 2014s

[5] Bhim Singh, P. Jayaprakash, D. P. Kothari, Ambrish Chandra, Kamal Al Haddad “Comprehensive Study of DSTATCOM Configurations” IEEE Transactions on Industrial Informatics, VOL. 10, NO. 2, MAY 2014

[6] Bhim Singh, Sabha Raj Arya “Design and control of a DSTATCOM for power quality improvement using cross correlation function approach” International Journal of Engineering, Science and Technology Vol. 4, No. 1, 2012, pp. 74-86, April 2012

[7] Alpesh Mahyavanshi, M. A. Mulla, R. Chudamani “Reactive Power Compensation by Controlling the DSTATCOM” International Journal of Emerging Technology and Advanced Engineering, Volume 2, Issue 11, November 2012

[8] N.M.G. Kumar1, P. Sangameswara Raju2 and P.Venkatesh “Control Of Dc Capacitor Voltage In A Dstatcom Using Fuzzy Logic Controller” International Journal of Advances in Engineering & Technology, July 2012, ISSN: 2231-1963

