ISSN : 2494-9150 Vol-01, Issue 12, MAR 2016.

A Novel Adaptive Control for DSTATCOM by using ANN

[1]Pallavi S. Jadhav, [2]R. K. Jha
[1]ME Student, [2]Lecturer, [1,2]SND College of Engineering & Research Center, Yeola, Maharashtra, India.
[1]pallavi_siddhai@rediffmail.com, [2]rakeshshanti@gmail.com

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.

Keywords — 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 [8], [9]. 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 [10] 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 [11].

III. SYSTEM DESCRIPTION

a) Introduction of DSTATCOM

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 ac voltage difference across the leakage reactance power exchange between the Power system and the DSTATCOM at the bus bar can be regulated to improve the voltage profile of the power system. This constitutes the primary duty of the DSTATCOM. However a secondary damping function is added in to the DSTATCOM for enhancing power system oscillation stability.

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.

b) Basic Configurations And Function of DSTATCOM

When used in low-voltage distribution systems, the STATCOM is normally identified as Distribution STATCOM (D-STATCOM). Figure 2.8 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.

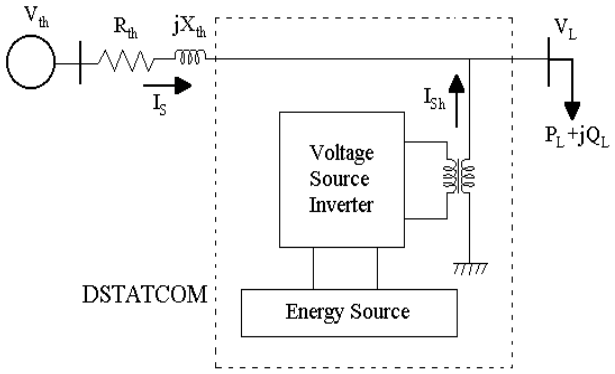

Figure 1 : Schematic Diagram of D-STATCOM

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 [9]. Functioning as same as the STATCOM system, 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 STATCOM system to be used three different purposes that is:

i. Voltage regulation and compensation of reactive power;

ii. Correction of power factor;

iii. Elimination of current harmonics

c) Main Components Of D-STATCOM

D-STATCOM consists of three main components that is Voltage Source Converter (VSC), Energy Storage Circuit, and it Controller system. Each one of this component play an important role to ensure that D-STATCOM can operate wisely without have any problems.

i) Voltage Source Converter (VSC)

Voltage Source Converter (VSC) is one of the power electronic device. VSC is the most important component in D-STATCOM and it can generate a sinusoidal voltage waveform with any required magnitude, with any required phase angle and also with any required frequency. Usually VSC is mostly used in Adjustable Speed Drive but it also can be used to mitigate the voltage sags. VSC is used to replace the voltage or to inject the 'missing voltage'. The missing voltage can be defined as the difference between the actual voltage and the nominal voltage. Normally, the converter is based on some kind of energy storage which will get the supply from the DC voltage. This converter is used the switching based on a sinusoidal PWM method [12]. The PWM offers simplicity and good response. The device that used for the switching is an IGBT power electronic device.

ii) Energy Storage Circuit.

In energy storage circuit, the DC source was connected in parallel with the DC capacitor. DC source is act as a battery that will supply a power meanwhile the DC capacitor is the main reactive energy storage element. It carries the input ripple current of the converter. To charge the DC capacitor, it could be used either a battery source or it could be recharged by the converter itself.

iii) Controller System

The aim of the controller system is to maintain the constant voltage magnitude at the point where a sensitive load is connected under system disturbances. The control system element can only measure the RMS voltage magnitude that measured at the load point. For the controller system there is no requirements of the reactive power measurements. The VSC switching order is based on a sinusoidal PWM technique which offers simplicity and good response. PWM methods offer a more flexible option for a low power application which is the existing system. Thus the new approach of using the artificial neural network controlled controller for DSTATCOM is proposed in this project.

A voltage source converter (VSC)-based DSTATCOM is connected to a three phase ac mains feeding three phase linear/nonlinear loads with internal grid impedance. The device is realized using six IGBTs (insulated gate bipolar transistors) switches with anti-parallel diodes. Three phase loads may be a lagging power factor load or an unbalance load or a nonlinear load. A RC filter is connected to the system in parallel with the load and the compensator to reduce switching ripples in the PCC voltage injected by switching of DSTATCOM. For reducing ripples in compensating current, interfacing inductors are used at AC side of VSC. The performance of DSTATCOM depends upon the accuracy of harmonic current detection. For controlling the DSTATCOM, the Back propagation, a neural network based control algorithm is used.

The DSTATCOM is operated for the compensation of lagging power factor balanced load to correct the power factor at source side or to regulate the voltage at PCC. In ZVR mode, DSTATCOM injects currents to regulate the PCC voltage at the desired reference value of the voltage and the source currents may be leading or lagging currents depending on the reference value of PCC voltage. The three basic operation modes of the D-STATCOM for the output current, I vary depending upon Vi.

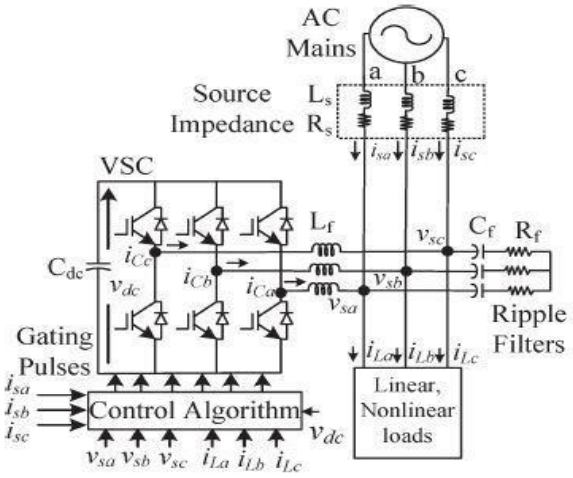

Figure 2. Circuit Diagram of VSC- Based DSTATCOM

iv) 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 .METHODOLOGY

Block Diagram Of ANN Controlled DSTATCOM

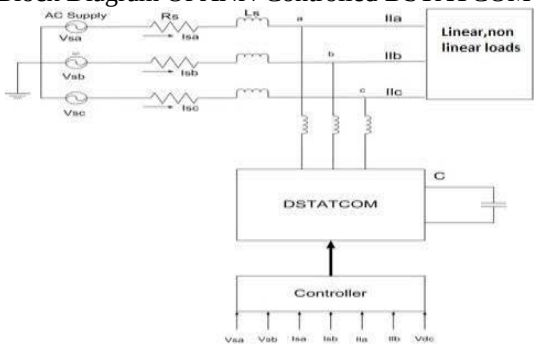

Figure 3. Block diagram of ANN controlled DSTATCOM

Figure 3.shows the block diagram of ANN controlled DSTATCOM which is used to improve the performance of the system under various operating conditions such as overloaded, faulty condition, and various power quality problems.

ANN based DSTATCOM gives the fast dynamic response, also gives accurate result as compared to other control methods such as PI controller, fuzzy logic controller etc.

V .CONCLUSION

A three phase VSC based DSTATCOM has been implemented for compensation of nonlinear 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 IGBTs of VSC of DSTATCOM. Various functions of DSTATCOM such as, load balancing and harmonic elimination have been demonstrated in PFC mode with DC voltage regulation of DSTATCOM., From this study, it is concluded that DSTATCOM and its control algorithm have been found suitable for compensation of nonlinear 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] S. Sherin Jasper -- Artificial Neural Network Controlled DSTATCOM For Power Quality Improvement, International Journal Of Innovative Research In Electrical, Electronics, Instrumentation And Control Engineering Vol. 3, Issue 5, May 2015

[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] Y. Xiao-ping, Z. Yan-ru, W. Yan, ―A Novel Control Method for DSTATCOM Using Artificial Neural Network, CES/IEEE 5th International Power Electronics and Motion Control Conference, 2006. IPEMC '06. Volume 3, 14-16 Aug. 2006, pp.1– 4.

[5] B. Singh, J. Solanki and V. Verma, ―Neural Network Based Control of Reduced Rating DSTATCOM,‖ Annual IEEE Conference, INDICON, 2005, 11-13 Dec. 2005 pp. 516 – 520.

[6] S. L. Pinjare, Arun Kumar M, "Implementation of Neural Network Back Propagation Training Algorithm on FPGA" International Journal of Computer Applications Volume 52– No.6, August 2012

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

[8] 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

[9] 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

[10] 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

[11] 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

[12] P. Mitra, G. K. Venayagamoorthy, ―Artificial Immune System Based DSTATCOM Control for an Electric Ship Power System‖, 39th IEEE Power Electronics Specialist Conference, PESC 2008, June 15-19, 2008, pp. 718-723.

