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A Review D-STATCOM Voltage Regulation Systems

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ABSTRACT: In this paper Compensator is a flexible ac transmission system (FACTS) controller, which can either absorb or deliver reactive power to a power system. Distribution Static Compensator (D-STATCOM) is proposed for compensation of reactive power and unbalance caused by various loads in distribution system. Distribution static compensator is based on the VSC principle. A D-STATCOM injects a current into the system to correct the voltage sag, swell and power factor. Distribution Static Synchronous Compensator (D-STATCOM) is an effective measure to maintain voltage stability and improve power quality of distribution grid. This paper deals with the modeling and control scheme of D-STATCOM. A stability analysis of D-STATCOM is obtained by bode plot approach.

Keywords: D-STATCOM, improve power quality, stability, reactive power.

I. INTRODUCTION

The high power quality is requested by manufacturing factories and commercial buildings dealing with information. This circumstance is caused by the fact that poor power quality gives the bad effects to the quality of products and therefore, results in financial losses. According to EPRI report (1995), the revenue losses due to poor power quality to U.S. business alone were $400 billion per year. Power quality problems are caused by dynamic or non-linear loads and interaction between the load and network. Outage, voltage sag and swell, voltage flicker, harmonic interference, and unbalance are some of the most common problems encountered. Today, new technologies known as Custom Power [1], using power electronics-based concepts, have been developed to provide protection from power quality problems. Generally, Custom Power equipments are divided by series-connected compensator like DVR (Dynamic Voltage Restorer), shunt-connected compensator like D-STATCOM (Distribution Static Compensator), and series and shunt compensator like UPQC (Unified Power Quality Compensator). In many instances, the use of Distribution Static Synchronous Compensator (D-STATCOM) can be some of the most cost-effective solutions for these types of power quality problems. When a fault happens in a distribution network, sudden voltage sag will appear on adjacent loads. D-STATCOM installed on a sensitive load, restores the line voltage to its nominal value within the response time of a few milliseconds thus avoiding any power disruption to the load. Currently, most of the STATCOM design studies are based on the assumption of the balanced three-phase system. And almost all researches are based on the three-phase three-wire systems Moreover this paper presents the D-STATCOM using IGBT voltage source inverter with 10 kHz switching frequency PWM operation for reactive power compensation in distribution system. AC voltage directs control has the advantages of improved harmonic performance, and sag voltage.

II. BASIC PRINCIPLE OF DSTATCOM

A DSTATCOM has been employed for compensation of unwanted components in distribution system, using adaptive filter based control algorithm on three-phase three-wire system. The adaptive filter based control algorithm has been used for extraction of reference transmission angle for ZVR mode of DSTATCOM in non-linear distribution system [2]. In all working condition, the DSTATCOM tries to maintain bus voltage to 1 pu value by injecting or absorbing reactive power to/from the ac system in ZVR mode.

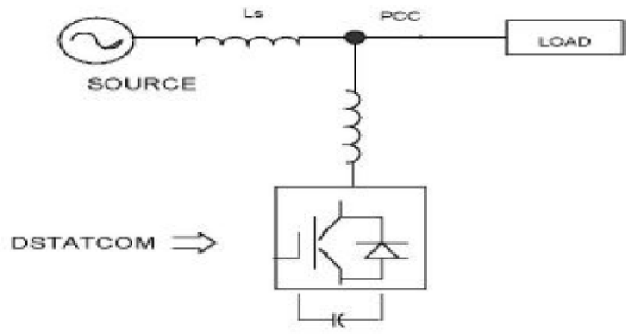

Fig. 1. Consists of a two-level Voltage Source Converter (VSC), a dc energy storage.

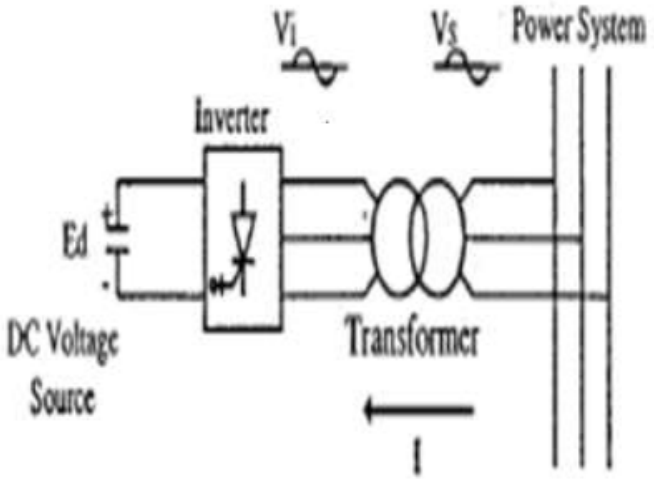

Fig. 2. Single line equivalent model of DSTATCOM.

The performance of DSTATCOM and its control has been found acceptable under varying load condition. D-STATCOM model focused on effect of capacitance towards ripple voltage and regulation in a test distribution system were developed using the PSCAD/EMTDC electromagnetic transient program. In this studies, the effect of the capacitance values of 1500 μF, 1800 μF, 2000 μF and 2430 μF have been investigated on the performance of the D-STATCOM. However, an optimum capacitance value of 2430 μF provides the lowest ripple voltage within the range of 8% considering an ideal voltage of 1.0 per unit. Capacitive and inductive load have been considered to to show the effectiveness of the D-STATCOM in providing continuous voltage regulation. In both cases, the D-STATCOM provides near its rated voltage to the distribution system. This study has been made the suitable capacitance value on the effectiveness of the [3] D-STATCOM in reducing ripple in a test distribution system. The improved simulation models, analyses on the capacitance values have been addressed and provided a better understanding of the compatibility between the DSTATCOM, the distribution system and loads. Thus, this model can be used as a basis for the development of prototype D-STATCOM. The custom power device DSTATCOM is connected in parallel with distribution system to improve the power quality. The simulation [4] that the voltage sag can be mitigated by connecting DSTATCOM to the distribution system. PWM control scheme only required for voltage measurement.

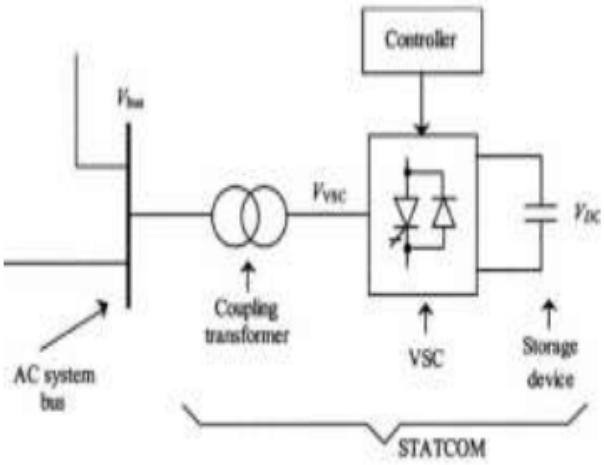

Fig. 3. Block Diagram of the voltage source converter based DSTATCOM.

Reactive power is produced when the current waveform is out of phase with the voltage waveform due to inductive or capacitive loads [5]. Current lags voltage with an inductive load, and leads voltage with a capacitive load. Only the component of current in phase with voltage produces real or active power. Major industrial loads for example transformers, furnaces, induction motors needs reactive power for sustaining magnetic field. The main reason for reactive power compensation is- the voltage regulation, increased system stability, [6] better utilization of machines connected to the systems, reducing system losses associated with the system. The DSTATCOM (Distribution Static Compensator) is a device used to control the flow of reactive power in distribution systems. A DSTATCOM is a fast response device that provides flexible voltage control at the point connection to the distribution feeder for reactive power compensation. The performance of the DSTATCOM depends on the control algorithm. So, for this, there are various control algorithms are used. This paper presents study of the reference current generation technique through decoupled current control i.e, p-q theory by using voltage source converter based DSTATCOM for reactive power compensation. Fourteen bus system is modeled and simulated using MATLAB SIMULINK and the results are presented. The simulation results of 14 bus system with and without [6] D-STATCOM are presented. Voltage stability is improved by using D-STATCOM. This system has improved reliability and power quality. The simulation results are in line with the predictions. The scope of present work is the modeling and simulation of fourteen bus system. The simulation and experimental verification of the VSI fed STATCOM system have been presented. The system configuration and operating principle of the VSI fed STATCOM have been discussed. The experimental results match with the simulation results. The limitation of this system with single STATCOM is that it can improve the voltages of the buses nearer to the STATCOM. Additional STATCOMs are required to improve the voltage of the other buses.

The power quality problems such as voltage dips, swells and interruptions, consequences, and mitigation [7] techniques of custom power electronic devices D-STATCOM. The design and applications of D-STATCOM for voltage sags, interruptions and swells, and comprehensive that the DSTATCOM provides relatively better voltage regulation capabilities. It was also observed that the capacity for power compensation and voltage regulation of DSTATCOM depends on the rating of the dc storage device.

This paper has been presented with design, operation, and control of a D-STATCOM operating in voltage control mode (VCM). After providing a detailed exploration of voltage regulation ability of D-STATCOM under nemorous feeder scenarios, a benchmark design procedure for selecting suitable value of L_ext with Fuzzy Logic Controller (FLC) is proposed. With this proposed method the D-STATCOM has improved voltage regulation ability with a reduced current rating VSI, reduced losses in the VSI and feeder [7]. Also, dynamic load reference voltage generation system allows D-STATCOM to set different constant reference voltage during voltage disorders . The proposed scheme with FLC THDs of load currents, V_pcc voltages have been reduced. The future work includes operation of this fixed inductor as a controlled reactor so that its effect can be minimized by varying its inductance.

The paper has presented a STATCOM controller for achieving better transient and angular stability**.** The validity and performance of the proposed controller are evaluated on a multimachine system. The developed robust PI regulator improves the voltage profile of the system by providing better reactive power support during the contingencies conditions than the conventional controller where the integrator saturates to a higher value under disturbed dynamics by feeding the controller with additional input signal.

An auxiliary controller in addition to STATCOM [8] line voltage controller is also proposed to efficiently damp out the low frequency oscillations. The wide area signal selection for the auxiliary controller is done on the basis of eigenvalue sensitivity. It can be concluded from the simulation results that the scheme involving combined action of both the proposed regulator and auxiliary controller has the ability to efficiently damp out the present mode of oscillations and provides superior performance as compared to the conventional and proposed controller along with fixed structure controller.

III. CONCLUSION

For the last three decades, a large scale integration of distributed generation (DG) is beginning to change the electrical distribution network from passive to active. Consequently, technical difficulties are created by significant impacts generated by DGs with voltage variation being the dominant effect. This paper deals with operation and control of a distribution static synchronous compensator (D-STATCOM) for power quality improvement in asynchronous machine-based distributed generation as the asynchronous generator has poor voltage regulation specially, during peak load conditions. Application of D-STATCOM as voltage controller improves the overall performance of the distribution system significantly. The power quality issues like voltage regulation, load balancing and power flow are being analyzed and simulated in MATLAB. The D-STATCOM is realized using a three leg IGBT based pulse width modulation voltage source converter (PWM-VSC) having a DC bus capacitor. A hystersis rule based carrier-less PWM current controller is used to derive gating pulses for the IGBT switches. The Simulink model is developed and simulated in MATLAB, version R2009a. It is observed that DSTATCOM is effective in compensating reactive power, load balancing and harmonic elimination and improving the power quality of the distribution system.

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