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Enhancement of Power Quality in Distribution Line using D - STATCOM

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***Abstract*—**This review paper deals with the performance, analysis of, operating principles of a new generation of power electronics based equipment called Distribution Static Compensator (D-STATCOM) aimed at enchancing the reliability, and quality of power flow in low voltage distribution network, and Simulation of a D-STATCOM (Distribution Static Compensator) used for voltage sag mitigation in distribution line. And it supplies power to sensitive loads under Islanding conditions. Power quality is an occurrence manifested as a nonstandard voltage, current or frequency that results in a failure of end use equipment. D-STATCOM is three phase voltage source converter used to compensate voltage and make the system stable by absorbing and generating reactive power. In order to mitigate power interruptions, voltage sag, improve harmonic distortion and low power factor. The proposed D-STATCOM is modeled and simulated using MATLAB/SIMULINK software.

***Keywords*—**DSTATCOM, Voltage sag, Voltage source converter, Power quality, MATLAB/SIMULINK, Load compensation support based on a pulse width modulated

1. INTRODUCTION

The FACTS technology opens up new opportunities for controlling power and enhancing the usable capacity of present, as well as new and upgraded, lines. Distribution staticsynchronous compensator (DSTATCOM) can comprehensively treat variety of power quality problems such as voltage fluctuation, flicker and harmonics pollution in distribution network [1].Voltage can be improved and power losses can be reduced by installing custom power devices at suitable location. These devices are aimed at enhancing the reliability and quality of power flows in low voltage distribution networks [2].Voltage sags are one of the most occurring power quality problems. For an industry voltage sags occur more often and cause severe problems and economical losses. Utilities often focus on disturbances from end-user equipment as the main power quality problems [3].

Reactive power compensation is an important issue in distribution system. If the reactive current increases, the system losses also increase. Various methods have been applied to mitigate voltage sags. For voltage sag mitigation we generally use capacitor banks, parallel feeder's etc. But the power quality problems are not completely solved by using these devices. Conventionally SVC has been used in conjunction with passive filters at distribution system for mitigating power quality problems. It provides reactive power compensation at transmission level. There are certain disadvantages for SVC they have limited bandwidth, higher passive element count

that increases size and losses. They have slow response also. These characters make them inapt for modern day distribution requirement [2].

The D-STATCOM has emerged as a promising device to provide not only for voltage sags mitigation but a host of other power quality solutions such as voltage stabilization, flicker suppression, power factor correction and harmonic control [4].

2. CONFIGURATION OF D-STATCOM

2.1 OVERVIEW

Depending upon the power rating of the statcom, different technologies are used for power converter. High power stations normally use GTO-based square wave voltage source converter. Lower power statcoms use IGBT based PWM (VSC).The reactive power output of the D-STATCOM inductive or capacitive depending can be either on the operation mode of the DSTATCOM.

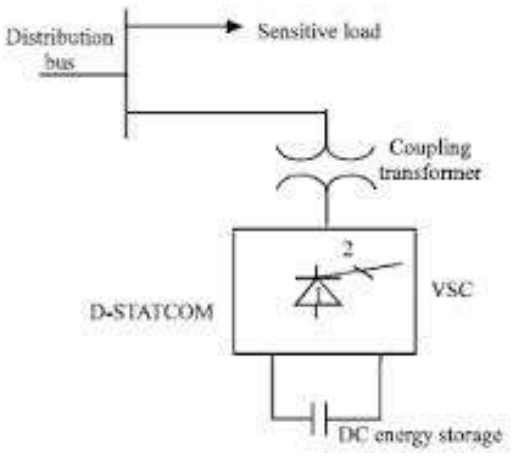


Figure 2.1. Schematic diagram of Statcom

DC side of the converter is connected to DC capacitor, carries the input ripple current of the converter and is the main energy storage element. The capacitor is charged by a battery source, or recharged by the converter. If the output voltage of VSC is equal to the AC terminal voltage, no reactive power is delivered to the system. If the output voltage greater than AC terminal voltage DSTATCOM is the capacitive mode of operation. The quantity of the reactive power is proportional to the voltage difference [2].The DSTATCOM mainly consists of DC voltage source behind self-commutated inverters using IGBT and coupling transformer. A three phase IGBT based current controlled voltage source inverter with a dc bus capacitor is used as a DSTATCOM.

D-STATCOM improves supply power factor, provide load balancing & improve load terminal voltage. DSTATCOM limits the short circuit current, improves the system transient stability limit and increases the load ability of the system. D-STATCOM controller is highly effective in improving the power quality at the distribution level by making the voltage stable [5].In figure 2.2.the STATCOM consists mainly of a PWM inverter connected to the network through a transformer. The dc link voltage is provided by capacitor C which is charged with power taken from the network. The control system ensures the regulation of the bus voltage and the dc link voltage. The D-STATCOM function is to regulate the bus voltage by absorbing or generating reactive power to the network, like a thyristor static compensator. The reactive power transfer is done through the leakage reactance of the coupling transformer by using a secondary voltage in phase with the primary voltage (network side). This voltage is provided by a voltage-source PWM inverter [J].

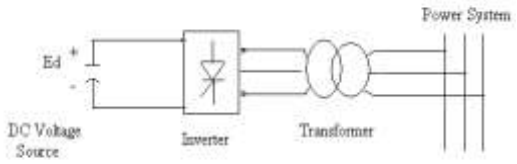
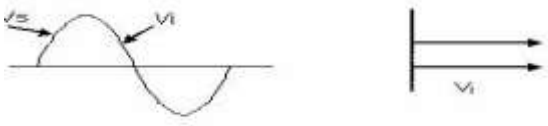
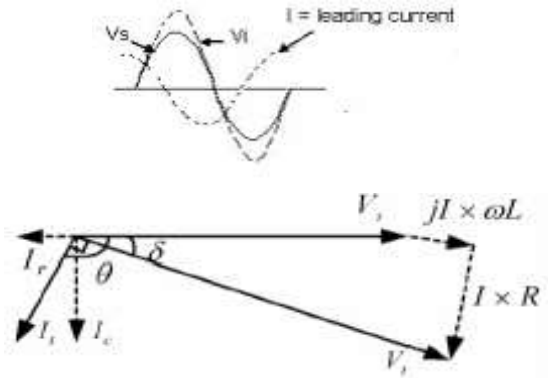


Figure 2.2 Single line equivalent model of dstatcom

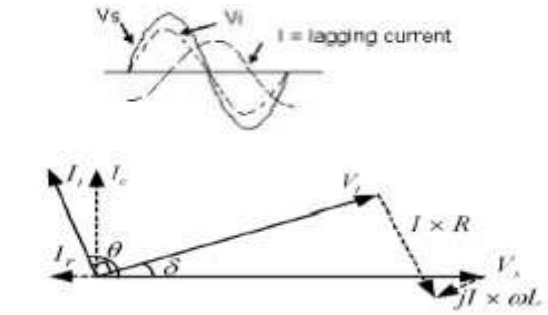
Figure 2.3. shows the three basic operation modes of the DSTATCOM output current, I, which varies depending upon Vi. If Vi is equal to Vs, the reactive power is zero and the D-STATCOM does not generate or absorb reactive power. When Vi is greater than Vs, the DSTATCOM shows an inductive reactance connected at its terminal. The current, I, flows through the transformer reactance from the D-STATCOM to the ac system, and the device generates capacitive reactive power. If Vs is greater than Vi, the D-STATCOM shows the system as a capacitive reactance. Then the current flows from the ac system to the D-STATCOM, resulting in the device absorbing inductive reactive power [4] [7].



a) No-load mode (Vs = Vi)



b) Capacitive mode (Vi >Vs)



c) Inductive mode (Vi <Vs)

Figure 2.3 Operation modes of D-STATCOM

3. METHODOLOGY

A DSTATCOM is utilized to eliminate the harmonics from the source currents and also balance them in addition to providing reactive power compensation to improve power factor or regulate the load bus voltage.

The block diagram of the proposed model is shown in figure 3.1. The industrial and domestic load shows the normal running load. At any specified time interval, a sudden load is included. The introduction of this sudden load introduces voltage sag. Hence if a DSTATCOM is connected in parallel to the distribution, it will correct the voltage sag in that interval [6].

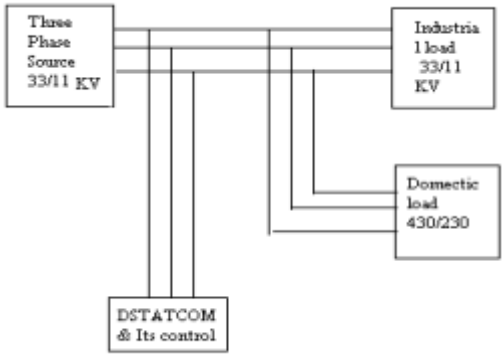


Figure 3.1 Schematic block diagram of D-STATCOM

3.1 Basic Operation of DSTATCOM

The D-STATCOM is three phase shunt connected power electronics based device. Shown in figure 3.2. It is connected near the load at the distribution system. It is also a one type of the voltage-source converter, which converts a DC input voltage into AC output voltage in order to compensate the active and reactive power needed by the system The DSTATCOM mainly consists of DC voltage source behind self-commutated inverters using IGBT and coupling transformer. D-STATCOM improves supply power factor, provide load balancing & improve load terminal

voltage. DSTATCOM limits the short circuit current, improves the system transient stability limit and increases the load ability of the system. D-STATCOM controller is highly effective in improving the power quality at the distribution level by making the voltage stable [5].

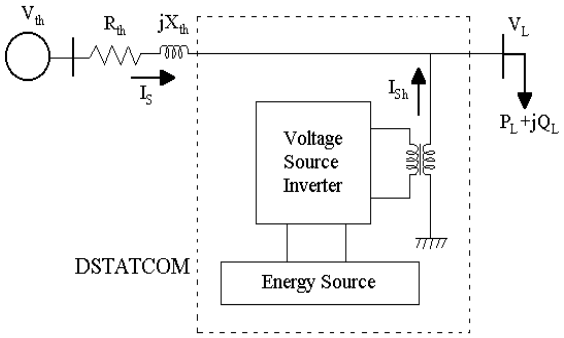


Figure3.2: Operation of DSTATCOM

3.2 Hybrid Arrangements

The D-STATCOM based hybrid arrangements can be used for both voltage regulation and load-compensating controllers. D- STATCOMs are usually combined with D-SVCs or passive harmonics filters. The former are most often used for voltage regulation, while the latter are utilized for load compensation. Both provide improvement of compensation capabilities [15].

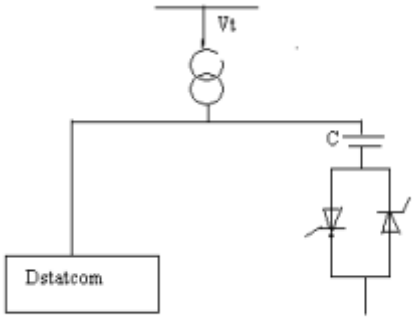


Figure 3.3 Hybrid D-STATCOM D-TSC controllers

4.VOLTAGE SOURCE CONVERTER (VSC)

A voltage Source converter is connected to bus via three phase transformer. A voltage source converter is a power electronics device, which can generate sinusoidal voltage with required magnitude frequency and phase angle. The VSC is used to either completely replace the voltage or to inject the missing voltage. Here missing voltage is the difference between the nominal voltage and the actual voltage. The solid-state electronics in the converter is then switched to get the desired output voltage. Normally the VSC is not only used for voltage sag/swell mitigation, but also for other power quality issues, e.g. flicker and harmonics [5].

5. ENERGY STORAGE CIRCUIT

From figure 5.1 DC source is connected in parallel with the DC capacitor. It carries the input ripple current of the converter and it is the main reactive energy storage element. This DC capacitor could be charged by a battery source or could be recharged by the converter itself [3].

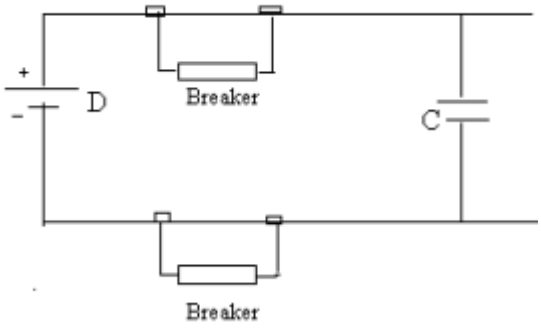


Fig.5.1 Circuit Diagram of DC Storage.

6. CONTROLLER

The aim of the control scheme is to maintain constant voltage magnitude at the point where a sensitive load is connected, under system disturbances. The control system only measures the r.m.s voltage at the load point, i.e., no reactive power measurements are required. This control is divided into two parts, that is, the sinusoidal pulse width modulation (SPWM) and reactive power control. The controller input is an error signal obtained from the reference voltage and the value r.m.s of the terminal voltage measured. Such error is processed by a PI controller

the output is the angle δ, which is provided to the PWM signal generator. It is important to note that in this case, indirectly controlled converter, there is active and reactive power exchange with the network simultaneously: an error signal is obtained by comparing the reference voltage with the r.m.s voltage measured at the load point shown in figure 6.1 The PI controller process the error signal generates the required angle to drive the error to zero, i.e., the load r.m.s voltage is brought back to the reference voltage [8]

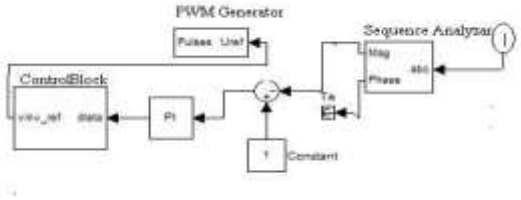


Figure 6.1 Simulink Controller Diagram

7. CONCLUSION

The power Quality improvement by using Distribution Static Compensator is presented in this paper. The results validate the principle if D-STATCOM for voltage regulate on applications. The simulation results show that the voltage sags can be mitigate by inserting D-STATCOM to the distribution system. The essential features of FACTS controllers and their potential to enhance system stability was addressed. The location and feedback signals used for design of FACTS-based damping controllers were discussed.

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