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POWER QUALITY IMPROVEMENT USING DSTATCOM

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Abstract - *The goal of this research is to use the MATLAB/Simulink software package to design and implement a three phase distribution level static synchronous compensator (D-STATCOM) for voltage regulation on a given test system. The success of the compensator will be determined by its ability to keep the voltage at 10 KV at the receiving end while also keeping both the voltage and current total harmonic distortion (THD) of the output at acceptable levels despite varying load and fluctuating system voltage. To justify the correct operation of the D-STATCOM, a series of tests will be run on a test system before and after the compensator is installed. Measurement comparison and mathematical analysis will be used to validate the D-successful STATCOM's operation. In order to design a suitable compensator, a brief examination of various control strategies, switching techniques, filtering options, converter types, and solid state switches will be included. Matlab/Simulink is used to model the DSTATCOM, which includes a 9-pulse IGBT-based voltage source inverter with fast inductive and capacitive compensation.*

Key Words **DSTATCOM, Matlab/Simulink, Total Harmonic Distortion (THD)**

1. INTRODUCTION

There has been a lot of interest in power quality in recent years. This is primarily due to an increase in nonlinear loads, such as power electronic converter-based adjustable speed drives, electronic ballasts, and so on, which has harmed power quality. Aside from voltage sag and swell, the main power quality issues are high reactive power burden, harmonic currents, load unbalance, and excessive neutral current. To address these issues, the utility employs FACTS (Flexible AC Transmission Systems) devices based on power electronics technology. According to power quality surveys, the existing distribution system faces a variety of power quality issues, with voltage sag and harmonics being the most stimulating issues faced by industrial consumers. A voltage dip is a brief decrease in the magnitude of the RMS voltage for a period ranging from half a cycle to several cycles. The use of voltage-sensitive loads such as adjustable speed drives (ASD), induction motors, computers, process control equipment, and so on causes voltage drop problems

Since many equipments are semiconductor-based and control is done with power electronic equipments, power quality has become an important issue in the last few decades. Flexible AC transmission system (FACTS) controllers can be used to effectively implement such control.

2. LITERATURE REVIEW

Ledwich and Ghosh (2002) conducted simulation studies on the DSTATCOM topology, which can be operated in either voltage or current control mode. To provide compensation, three single phase VSC are connected in parallel in this topology. Ghosh and Ledwich (2003) discussed load compensation with DSTATCOM when the load is located far away from the supply. They demonstrated that if the source is stiff, distortion in source currents and voltage will occur, which can be avoided by connecting a capacitor in parallel with the DSTATCOM.

Muni B et al. proposed a PWM inverter-based DSTATCOM for faster compensation (2003). They created the DSTATCOM, which is used to improve power factor. Sabin and Sannino proposed custom power devices such as DSTATCOM, which include power converters, injection transformers, and energy storage modules capable of performing reactive power compensation and harmonic mitigation in a distribution system to improve power quality (2003)

Wei Neng Chang and Kuan Dih Yeh (2003) proposed a DSTATCOM for unbalanced distribution system load compensation.The feed forward compensation scheme with symmetrical components method is used for fast response requirements. Emadi (2004) used the generalised state-space averaging method to model power electronic loads.He also examines the effects of these factors in ac distribution systems. Esfandiari et al. propose a new control strategy for the shunt active filter in three-phase three-wire systems with zero sequence voltages (2004). They used a simplified power distribution system model with ideas similar to field oriented control of three phase ac machines. Tanaka et al. propose using the correlation function a novel method of compensating harmonic currents generated by consumer electronic equipment that acts as harmonic voltage sources (2004). The distribution transformer has an additional winding on the secondary side, and a single-phase voltagesource Pulse-Width-Modulated (PWM) inverter is connected to the added winding, acting as a shunt-active filter.

Salem Rahmani et al. (2010) created a nonlinear control technique for a three-phase shunt active power filter that compensates for reactive, unbalanced, and harmonic load currents. Through linearization of the inherently nonlinear system model, they derive a proportional-integral (PI) control law to control reference currents and dc capacitor voltage independently

3. CONTROLLER DESIGN

Any compensation scheme should have a quick response time, be flexible, and be simple to implement. This project compares the following DSTATCOM schemes for reactive power compensation and power factor correction, which are based on:

1. Controlling Phase Shift
2. Decoupled Current Control is a term used to describe a method of controlling current that (p-q theory)
3. Method of the Synchronous Reference Frame (SRF)

Following the selection of an appropriate switching technique, it was critical to design the control loops correctly. It is critical to ensure that the correct parameters are being measured in order to achieve the desired control. Having previously chosen the constant DC link voltage D-STATCOM Control method, it was also demonstrated in previous chapters how the relationship between the magnitudes of VSTATCOM and VGRID governs the direction and amount of reactive power absorbed from or injected into the system.

The system was validated under voltage sag conditions, and the test results revealed that DSTATCOM with SPWM control scheme provides relatively improved voltage regulation capabilities in each case. The PWM control scheme only necessitates voltage measurements. Because of this, it is ideal for low-voltage custom power applications. The control scheme was tested under a wide range of operating conditions and found to be very robust.

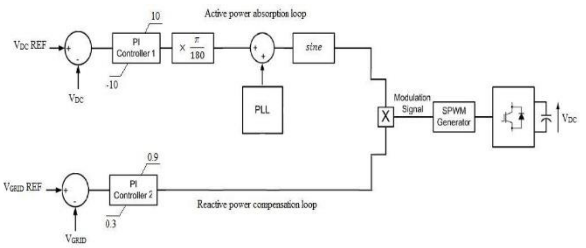

Fig 1 Control scheme's implementation

The DSTATCOM system's robust performance leads to the conclusion that it is a much acceptable device for improving power quality at the distribution end. It has also been explained how the phase angle between the two voltages determines the direction and amount of real power transferred. As a result, in order to implement the chosen control strategy, two variables must be measured. They are the magnitude of the grid voltage and the voltage of the DC link. Because of the fast response times and robust level of control that PI controllers can achieve, they are commonly used for control.

4. RESULTS AND DISCUSSION

Table-1 Parameters used to simulate D-STATCOM

Source parameters	415volts(rms),3phase,50Hz Ls =0.1H Rs =0.8929ohms
Line parameters	1ohms 1mH
DC link initial voltage	415volts
DC link capacitance	50mF
Filter Inductance	0.595H
Filter Capacitance	98Mf
Load Active Power	3KW
Inductive load put on after 0.1sec	1.7kw
Line Frequency	50Hz

The Cascaded H-Bridge Multilevel Inverter (CHBMI) is built by connecting single phase H-Bridge inverters with separate DC sources in series. The cascaded H-bridges inverter with separated dc sources is discussed in this research.

The simulated model block diagram of a power system is shown in Fig.2. It consists of an AC supply source of 415v 50 hertz 3phase with a source resistance of 0.8929 ohms and a source impedance of 0.1 H, and the source voltage and current are measured using the VI measurement block, with the source voltage being given to the controller block. To operate in the abc to dqo reference frame, a Phase Locked Loop (PLL) is used to synchronise the control loop to the ac supply. The RLC block is used to simulate the transmission line parameters. Where resistance is assumed to be 0.1 ohms and inductance is assumed to be 0.01 Henry, we are considering two sets of load, one of which is always of rating 1kw, 100var connected to the line and another of rating 100w, 1.7kvar which is highly inductive and is taken into account to show voltage sag. Which is turned on after 0.1 seconds of simulation at the point of common coupling VI measurement block is used to measure voltage and current at PCC.

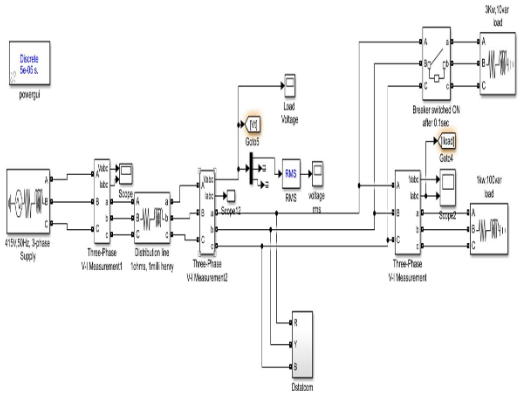

Figure 2-Simulation of power system with DSTATCOM and loads

DSTATCOM block diagram is shown in the figure. 3. It consists of voltage source inverter and controllerblock with synchronous reference frame.

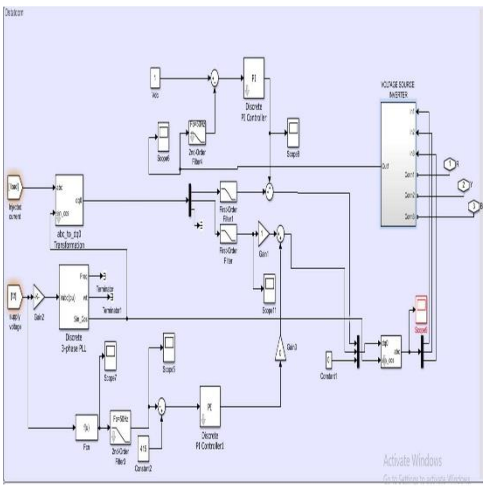

Figure.3 Controller block diagram

Voltage sag is initiated in the system by connecting an extra load at 0.1 sec, here the additional load is connected to the power system from 0.1s to 0.5s. Thus, during this time period the voltage at the load bus i.e., at the point of coupling (PCC) drops form 315v to 240v shown in Fig. 4.

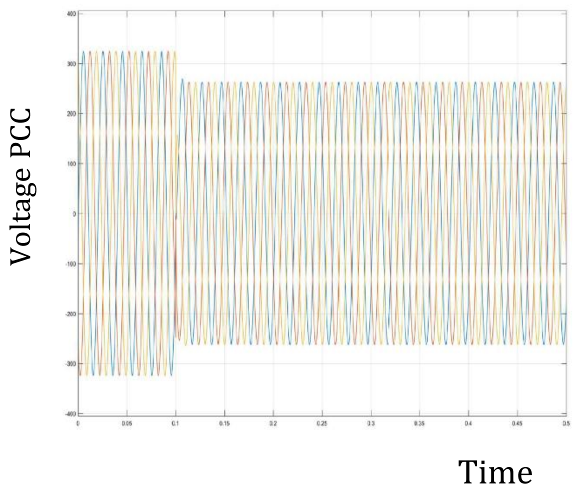

Figure4. Voltage at PCC at 0.1 sec the highly inductive load is added in order to show the drop in voltagelevel at point of common coupling without DSTATCOM.

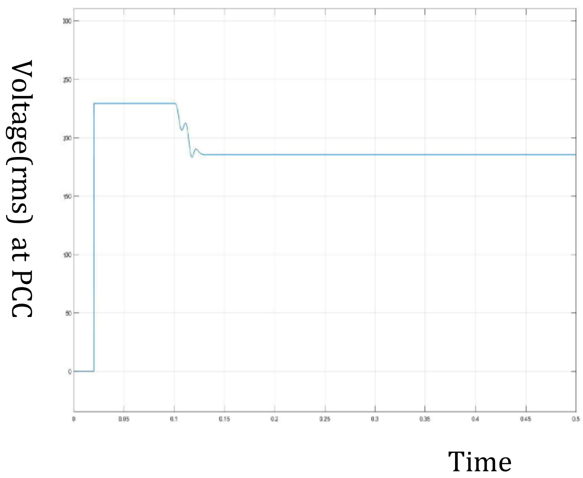

Fig. 5 voltage(rms) at PCC at 0.1 sec the highly inductive load is added in order to show the drop in voltage level at point of common coupling without DSTATCOM.

The voltage sag and rms voltage measurements are taken as the voltage decreases from its reference (rated) value, as shown in Fig.5. The DSTATCOM generates a compensation voltage in addition to the supply voltage to compensate for this voltage drop.

Fig. 6 depicts the output voltage waveform at the point of common coupling. The simulation begins at 0 sec with an active load of 3 Kilowatt in order to demonstrate how DSTATCOM mitigates voltage sag. A highly inductive load of 1.7 Kilowatt is added to the system at 0.1 sec, and a dip in the voltage at the PCC can be seen in fig.6 at 0.1 sec, the DSTATCOM is turned on as soon as the extra load is added the controller.

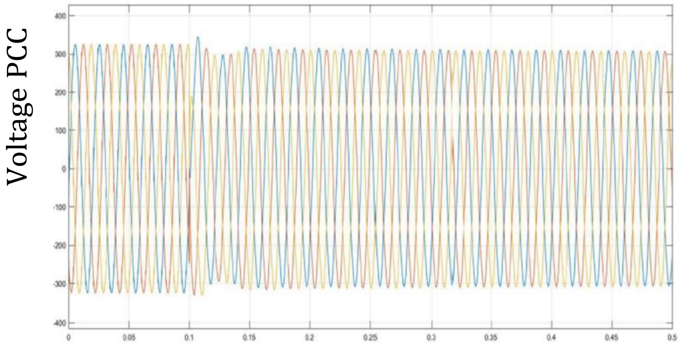

Figure6. voltage waveform at point of common coupling with DSTATCOM

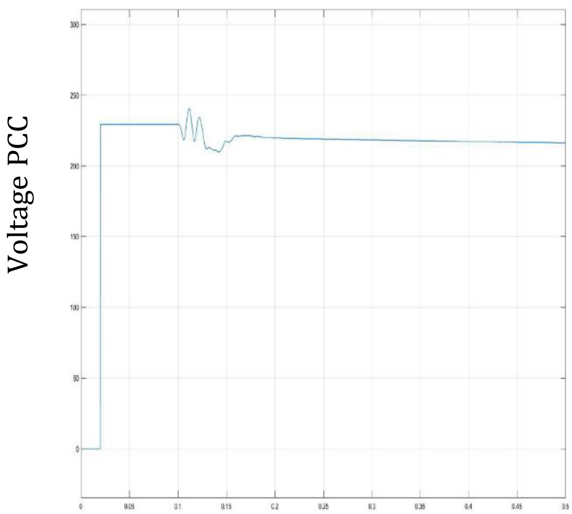

Fig. 7 voltage wave form at point of common coupling with DSTATCOM

D-STATCOM mitigates the voltage sag of 0.81pu to 0.95pu. Voltage The resultant dip in the voltageat the PCC in per unit is shown in Fig.7

5 CONCLUSION

The system was validated under voltage sag conditions, and the test results revealed that DSTATCOM with SPWM control scheme provides relatively improved voltage regulation capabilities in each case. The PWM control scheme only necessitates voltage measurements. Because of this, it is ideal for low-voltage custom power applications. The control scheme was tested under a wide range of operating conditions and found to be very robust. The DSTATCOM system's robust performance leads to the conclusion that it is a much acceptable device for improving power quality at the distribution end.

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