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Power quality enchancement in distribution system using dstatcom

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Abstract

Modern industrial devices are mostly based on the electronic devices such as programmable logic controllers and electronic drives. The electronic devices are very sensitive to disturbances and become less tolerant to power quality problems such as voltage sags, swells and harmonics. Voltage dips are considered to be one of the most severe disturbances to the industrial equipment's. Voltage support at a load can be achieved by reactive power injection at the load point of common coupling. This paper presents the systematic procedure of the modeling and simulation of a Distribution STATCOM (DSTATCOM) for power quality problems, voltage sag and swell based on Sinusoidal Pulse Width Modulation (SPWM) technique. Power quality is an occurrence manifested as a nonstandard voltage, current or frequency that results in a failure of end use Equipment's. D-STATCOM injects a current in to the system to correct the voltage sag and swell. The control of the Voltage Source Converter (VSC) is done with the help of SPWM. The proposed D-STATCOM is modeled and simulated using MATLAB/SIMULINK software.

Keywords: D-STATCOM, Power quality problems, SPWM, Voltage sag and swell

Introduction

An increasing demand for high quality, reliable electrical power and increasing number of distorting loads may lead to an increased awareness of power quality both by customers and utilities. The most common power quality problems today are voltage sags, harmonic distortion and low power factor.Voltage sag is caused by a fault in the utility system, a fault within the customer's facility or a large increase of the load current, like starting a motor or transformer energizing .Voltage sag is one of the most occurring power quality problems. For an industry voltage sags occurs more often and cause severe problems and economical losses. Utilities often focus on disturbance from end-user equipment as the main power quality problems [3].

Distribution static compensator (DSTATCOM)

D-STATCOM consists of a two-level VSC, a dc energy storage device, controller and a coupling transformer connected in shunt to the distribution network. Figure.1 shows the schematic diagram of D-STATCOM [4]

$$= \mathbf{I_L - I_s = I_L - \frac{V_{th} - V_L}{Z_{th}}} \qquad (1)$$

$$\mathbf{I_{out} < \gamma = I_L < (-\theta) - \frac{V_{th}}{Z_{th}} < (\delta - \beta) + \frac{V_L}{Z_{th}} < (-\beta)} \qquad (2)$$

Output current, will correct the voltage sags by adjusting the voltage drop across the system impedance, ($Z_{th} = R + jX$). It may be mention that the effectiveness of D-STATCOM in correcting voltage sags depends on: a) The value of Impedance, $Z_{th} = R + jX$ b) The fault level of the load bus

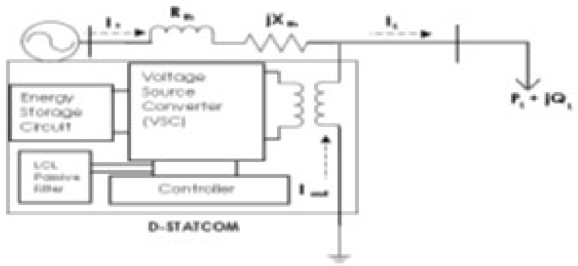

Figure.1 Schematic diagram of a D-STATCOM

Voltage source converter (VSC)

A voltage-source converter is a power electronic device that connected in shunt or parallel to the system. It can generate a sinusoidal voltage with any required magnitude, frequency and phase angle. The VSC used to either completely replace the voltage or to inject the 'missing voltage'. The 'missing voltage' is the difference between the nominal voltage and the actual. It also converts the DC voltage across storage devices into a set of three phase AC output voltages [7].

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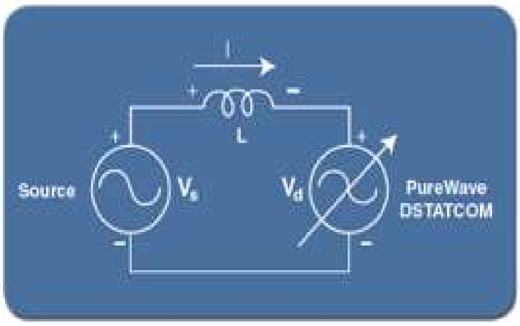

Figure.2 Voltage Source Converter

In addition, D-STATCOM is also capable to generate or absorbs reactive power. If the output voltage of the VSC is greater than AC bus terminal voltages, D-STATCOM is said to be in capacitive mode. So, it will compensate the reactive power through AC system and regulates missing voltages. These voltages are in phase and coupled with the AC system through the reactance of coupling transformers.

Controller

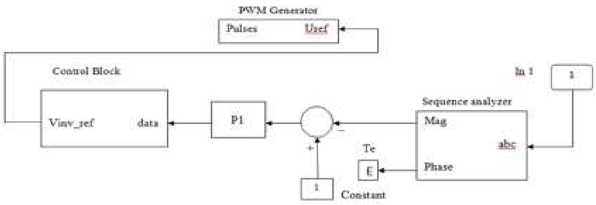

Figure.3 Block Diagram of Controller System

Figure.3 shows the block diagram of Controller system. The controller system is partially part of distribution system. Proportional-integral controller (PI Controller) is a feedback controller which drives the system to be controlled with a weighted sum of the error signal (difference between the output and desired set point) and the integral of that value. In this case, PI controller will process the error signal to zero. The load RMS voltage is brought back to the reference voltage by comparing the reference voltage with the RMS voltages that had been measured at the load point. It also is used to control the flow of reactive power from the DC capacitor storage circuit. PWM generator is the device that generates the Sinusoidal PWM waveform or signal. To operate PWM generator, the angle is summed with the phase angle of the balance supply voltages equally at 120 degrees. Therefore, it can produce the desired synchronizing signal that required. PWM generator also received the error signal angle from PI controller. The modulated signal is compared against a triangle signal in order to generate the switching signals for VSC valves.

Simulation model and results

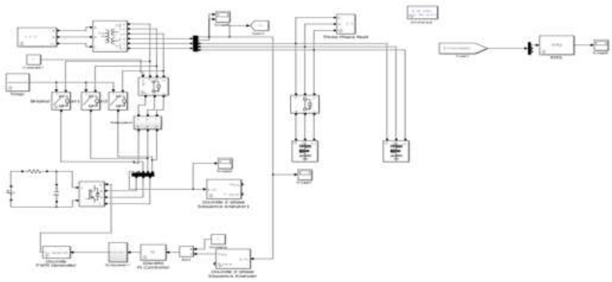

Figure.4 MATLAB/SIMULINK model to carry out the D-STATCOM simulations

To create distortion in the distribution system, different types of fault are injected to study the role of DSTATCOM in mitigating the disturbances.

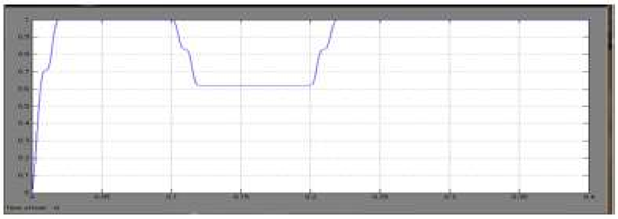

Figure.5 V_{rms} at load point with three-phase short circuit fault without DSTATCOM

Figure.5 shows voltage without D-STATCOM and with three-phase short-circuit fault applied at point A, via a fault resistance of 0.2 full, during the period 300-600 ms. The voltage sag at the load point is 36% with respect to the reference voltage.

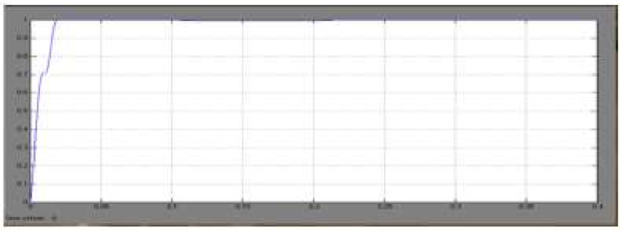

Figure.6 Vrms at load point with three-phase short circuit fault with DSTATCOM

When D-STATCOM is connected to the system with three phase short circuit fault, the voltage sag is mitigated almost completely, and the RMS voltage at the sensitive load point is maintained at 99% as shown in figure.6.

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Figure.7 V_{rms}at load point with three phase-ground fault without D-STATCOM

Figure.7 shows voltage without DSTATCOM and a three phase-ground fault is applied at point A, via a fault resistance of 0.4 Ω, during the period 300-600 ms. The voltage sag at the load point is 30% with respect to the reference voltage.

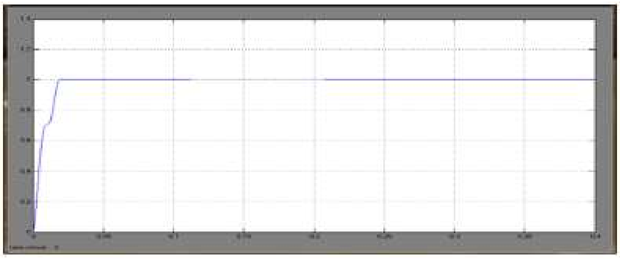

Figure. 8 V_{rms} at load point with three phase ground fault with D-STATCOM

Figure. 8 shows voltage with D-STATCOM is connected to the system; the voltage sag is mitigated almost completely.

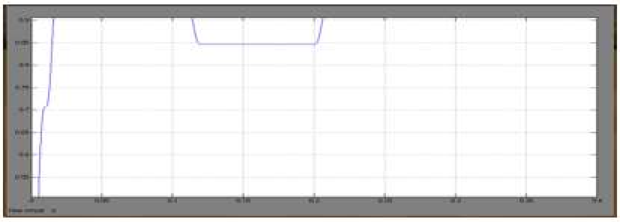

Figure.9 V_{rms} at load point with line-ground fault without D-STATCOM

Figure.9 shows voltage with line to ground fault is applied at point A, via a fault resistance of 0.4 Ω during the period 300-600 ms. The voltage sag at the load point is 20% with respect to the reference voltage.

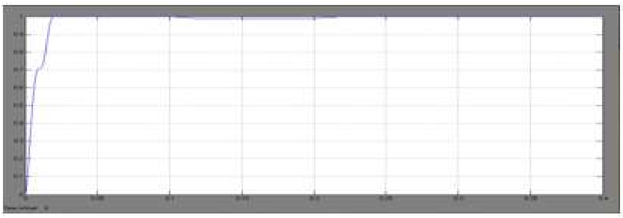

Figure.10 V_{rms} at load point with line-ground fault with D-STATCOM

Figure.10 shows voltage with D-STATCOM is connected to the system and with line to ground fault, the voltage sag is mitigated almost completely.

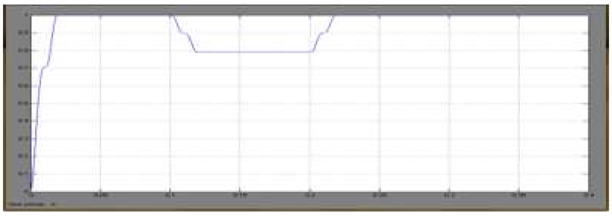

Figure.11 V_{rms} at load point with line-line fault without DSTATCOM

Figure.11 shows voltage with D-STATCOM and a line ground fault is applied at point A, via a fault resistance of 0.4 Ω, during the period 300-600 ms. The voltage sag at the load point is 20% with respect to the reference voltage.

Figure.12 V_{rms} at load point with line-line fault with DSTATCOM

Conclusion

This paper has presented the power quality problems such as voltage sags and swell. Compensation techniques of custom power electronic device D-STATCOM was presented. The design and applications of D-STATCOM for voltage sags, swells and comprehensive results were presented. The Voltage Source Convert (VSC) was implemented with the help of Sinusoidal Pulse Width Modulation (SPWM). The simulations carried out showed that the DSTATCOM provides relatively better voltage regulation capabilities and voltage sags can be mitigate by inserting DSTATCOM to the distribution system.

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