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Enhancement of Power Quality in Distribution System Using D-STATCOM

KEYWORDS: D-STATCOM, Voltage Sags, Voltage Source Converter (VSC), Total Harmonics Distortion (THD)

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ABSTRACT *This paper presents the enhancement of voltage sags, harmonic distortion and low power factor using Distribution Static Compensator (D-STATCOM) in distribution system. The model is based on the Voltage Source Converter (VSC) principle. The D-STATCOM injects a current into the system to mitigate the voltage. The different simulations with R,RL and RLC were performed using MATLAB SIMULINK version R2010b with and without D-STATCOM.*

1.INTRODUCTION:

An increasing demand for high quality, reliable electrical power and increasing number of distorting loads may leads 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 sags is a short time (10 ms to 1 minute) event during which a reduction in r.m.s voltage magnitude occurs [4].

It is often set only by two parameters, depth/magnitude and duration. The voltage sags magnitude is ranged from 10% to 90% of nominal voltage and with duration from half a cycle to 1 min. Voltage sags 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 [2, 3].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 [5].

Harmonic currents in distribution system can cause harmonic distortion, low power factor and additional losses as well as heating in the electrical equipment. It also can cause vibration and noise in machines and malfunction of the sensitive equipment. The development of power electronics devices such as Flexible AC Transmission System(FACTS) and customs power devices have introduced and emerging branch of technology providing the power system with versatile new control capabilities [1].There are different ways to enhance power quality problems in transmission and distribution systems. Among these, the D-STATCOM is one of the most effective devices. A new PWM-based control scheme has been implemented to control the electronic valves in the DSTATCOM.

The D-STATCOM has additional capability to sustain reactive current at low voltage, and can be developed as a voltage and frequency support by replacing capacitors with batteries as energy storage. [6, 7]

2. DISTRIBUTION STATIC COMPENSATOR (D-STATCOM)

A 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 2.1 shows the schematic diagram of D-STATCOM.

$$I_{out} = I_L - I_S = I_L - \frac{V_{th} - V_L}{Z_{th}} \quad (2.1)$$

$$I_{out} < \gamma = I_L < (-\theta) - \frac{V_{th}}{Z_{th}} < (\delta - \beta) + \frac{V_L}{Z_{th}} < (-\beta) \quad (2.2)$$

$I_{out} = output\ current$ $I_L = load\ current$
$I_S = source\ current$ $V_{th} = Thevenin\ Voltage$
$V_L = load\ voltage$ $Z_{th} = impedance$

Referring to the equation 2.2, output current, I_{out} 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

1. 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 [8, 9].

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. Suitable adjustment of the phase and magnitude of the DSTATCOM output voltages allows effectives control of active and reactive power exchanges between D-STATCOM and AC system. In addition, the converter is normally based on some kind of energy storage, which will supply the converter with a DC voltage [10].

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2. CONTROLLER

Figure 2.2 shows the block diagram of Controller system. The controller system is partially part of distribution system.

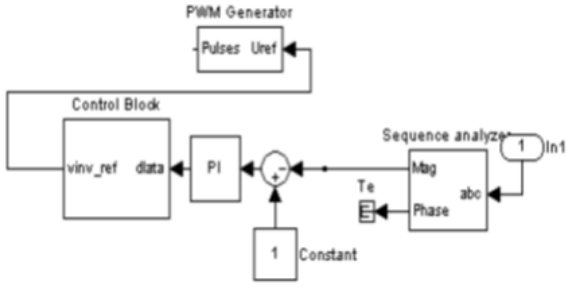


Figure 2.2.Block Diagram of Controller System

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 r.m.s voltage is brought back to the reference voltage by comparing the reference voltage with the r.m.s 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.

3. Summary of THD with and without D-STATCOM

Table 3.1 Graphical representation of THD without insertion of D-STATCOM

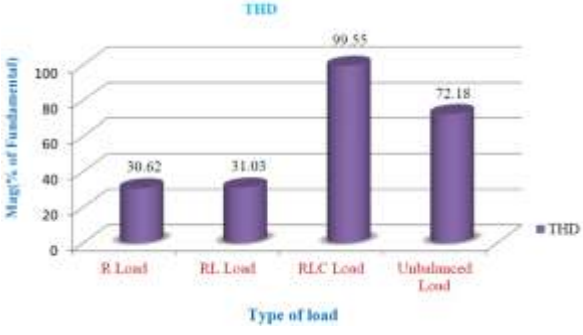
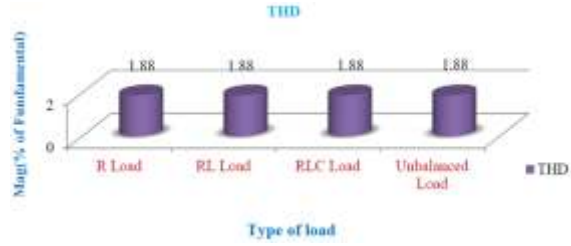


Table 3.2 Graphical representation of THD with insertion of D-STATCOM



4.Conclusion

In this paper simulations are carried out with different loads connected through rectifier and unbalanced load with and without D-STATCOM and obtained the THD.

The value of THD varies from 30.62 to 99.55 without D-STATCOM. The similar cases are simulated with insertion of D-STATCOM and found drastic improvement in the Value of THD. It is equally reduced to 1.88 in all the cases.

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