Power Quality Improvement in Distributed Generation Systems Incorporating D-STATCOM

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ABSTRACT: Distribution systems are section of power systems design and developed for the operation of power sharing to the end users and among power pools. In present era distribution system are also intact with small generation systems distributed throughout the local distribution network termed distributed generation. In this research article distributed generation power quality with the use of D-STATCOM. D-STATCOM modeling along with Space Vector PWM effects to control the power quality is analyzed. Shunt controllers were connected in between the systems for voltage regulation and power quality control, due to shunt connections coordinated control power electronics controllers will be controlling reactive power in the systems.

KEYWORDS: D-STATCOM, PWM, STATCOM, SVPWM.

I. INTRODUCTION

As in this era centralized generation were producing power in bulk and routing to power pools, but line losses and operation costs were also to be considered. In remote area where power pool distribution system lying is costlier then generation at that place though in small rating and by renewable means is encouraging. In power distribution due to various line losses uniform voltage profile, power factor, active and reactive power maintainace is not possible without compensation and controlling arrangements. Shunt controllers are utilized for controlling reactive power in the systems thus maintaining the flat voltage profile. With the advancement of technology and introduction of power electronics controller, distributed shunt controller which are capable of controlling power flow and quality were utilized with distributed and dispersed generation. Static Compensators are working in two methodologies having power spinning reserve for systems voltage and reactive power compensation and without reserves direct compensation with utility of capacitors.

Since 1981 power electronics device switch mode power supply is introduced into market which is generating distorted sinusoidal current without rotating devices, only by the switching technique. SMPS became popular as power electronics advances but this led to introduction of harmonics in the utility systems. Harmonics were cause of this switching and power electronics devices as the additional incoherent generation which is in addition to fundamental power. As harmonics were creating many problems in which inefficient control and delay of operation led to collapse of system which is adverse consequence's as in every 10 second the feedback of power systems operation is to be send to transmission system operator (TSO).

II. AN OVERVIEW OF STATCOM

STATCOM technology has been extensively studied and developed in transmission systems to regulate voltage by adjusting its reactive power into the power system, whereas UPFC was designed to control real- and reactive-power flows between two substations. On the other hand, D-STATCOM and APF are suitable for power quality improvement of the distributed power system, such as harmonic compensation, harmonic damping, and reactive-power compensation. Recommended limits are provided for both individual harmonic components and the total demand distortion. The concept of PCC is illustrated in figure1. These limits are expressed in terms of a percentage of the end user's maximum demand current level, rather than as a percentage of the fundamental. This is intended to provide a common basis for evaluation over time.

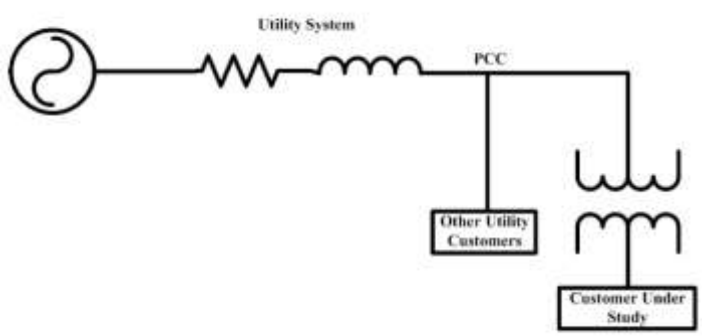

Figure Error! No text of specified style in document. **PCC at the Transformer Primary**

III. STATIC SYNCHRONOUS COMPENSATOR

A static synchronous compensator (STATCOM), also known as a "static synchronous condenser" ("STATCOM"), is a regulating device used on alternating current electricity transmission networks. It is based on a power electronics voltage-source converter and can act as either a source or sink of reactive AC power to an electricity network. If connected to a source of power it can also provide active AC power. It is a member of the FACTS family of devices.

IV. FOURIER SERIES AND ANALYSIS

The Fourier analysis of the harmonics for output power and power factor is known as Total Harmonic Distortion (THD). It is done with the help of FFT analysis and based on the result the given system can be justified. The THD is the analysis of the whole power system that the system is persistent to harmonics and fast response to remove it.

The Fourier series is the periodic function of non-sinusoidal waveform given by f (t) and can be expressed as:

$$f(t) = F_o + \sum_{k=1}^{\infty} f_k(t) \qquad \text{…………. 3.1}$$

$$f(t) = \frac{1}{2}a_o + \sum_{k=1}^{\infty}\{a_k \cos(k\omega t) + b_k \sin(k\omega t)\} \qquad \text{…………. 3.2}$$

where f (t) is periodic function of non-sinusoidal waveform

$F_o = \frac{1}{2}a_o$ is the average value of the function f(t)

$$a_o = \frac{1}{2\pi}\int_0^{2\pi} f(t)d\omega t \qquad \text{…………. 3.3}$$

$\omega = \frac{2\pi}{T}$ is the angular velocity

$T = \frac{1}{f}$ is the periodic interval of time.

where f is the fundamental frequency.

$$a_k = \frac{1}{\pi}\int_0^{2\pi} f(t)\cos(k\omega t)\, d\omega t \qquad ; k = 1,2,3 \qquad \text{………….. 3.4}$$

$$b_k = \frac{1}{\pi}\int_0^{2\pi} f(t)\sin(k\omega t)\, d\omega t \qquad ; k = 1,2,3 \qquad \text{………….. 3.5}$$

where a_k and b_k are the Fourier coefficients.

In three - phase Distribution Generation System (DGS) the distorted waveform is contains the harmonic current which contains multiple integer of fundamental frequency. A purely sinusoidal waveform does not contain harmonics. The harmonic current is the multiple integer of the fundamental frequency according to the harmonics present in the three phase converter connected to the DGS, harmonics frequency will be as shown in the following table 1

Table 1. Order of Harmonic Pulses and their Frequencies

Order Of Harmonic (k)	**Rectifier Pulse Number**				**Harmonic Base frequency ($f_h = f_n * k$)**
	6	**12**	**18**	**24**	
5	**Y**				**250**
7	**Y**				**350**
11	**Y**	**Y**			**550**
13	**Y**	**Y**			**650**
17	**Y**		**Y**		**850**
19	**Y**		**Y**		**950**
23	**Y**	**Y**		**Y**	**1150**
25	**Y**	**Y**		**Y**	**1250**
29	**Y**				**1450**
31	**Y**				**1550**
35	**Y**	**Y**	**Y**		**1750**
37	**Y**	**Y**	**Y**		**1850**

f_n = 50 Hz is the fundamental frequency

V. SPACE VECTOR TECHNOLOGY

One of the most popular techniques for pulse width modulation (PWM) is Space Vector Pulse Width Modulation (SVPWM). SVPWM has the highest voltage utilization ratio and is developed from the magnetic flux trajectory control in the speed control of an AC motor. In this technique the space vectors are representing the output voltages of the inverter.

VI. MODEL DESCRIPTION

The simulated model of the 4-bus distributed generation system is shown in figure 2. In this model the supply is given by 3-phase programmable voltage source in which phase and frequency can be pre-programmed. In this test system the supply is 415v, 50Hz and at phase angle of 0 deg is supplied to the primary (source) bus 1.

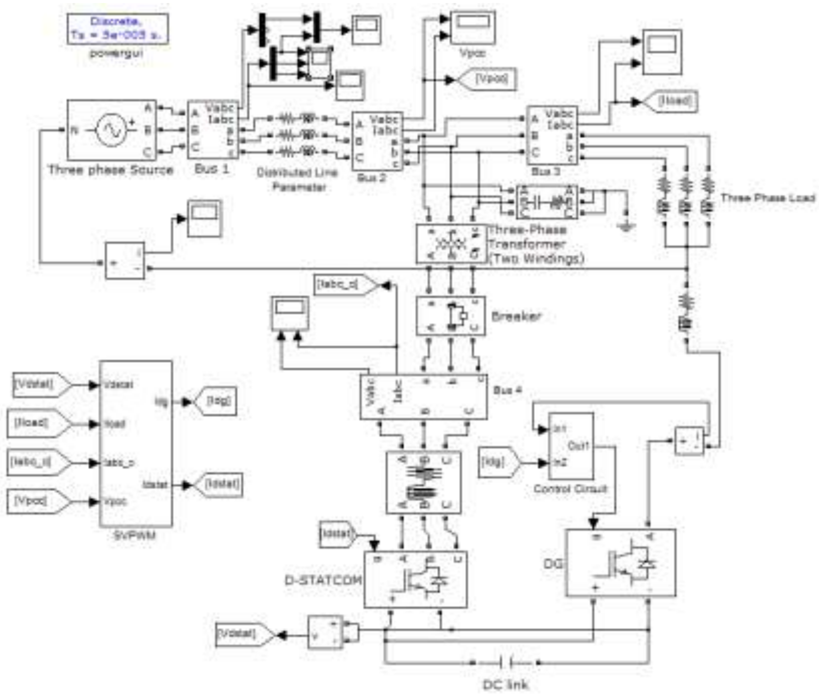

Figure 1 SIMULINK Model 4-bus Distribution Generation System

VII. RESULT ANALYSIS

The output voltage waveform is shown below in figure 3. The result shows that the voltage profile is improved than the result obtained the point of common coupling (PCC).

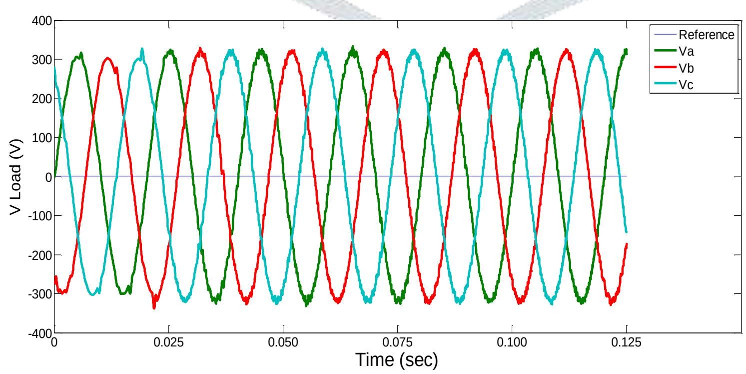

Figure 3. Output Voltage Waveform at Load

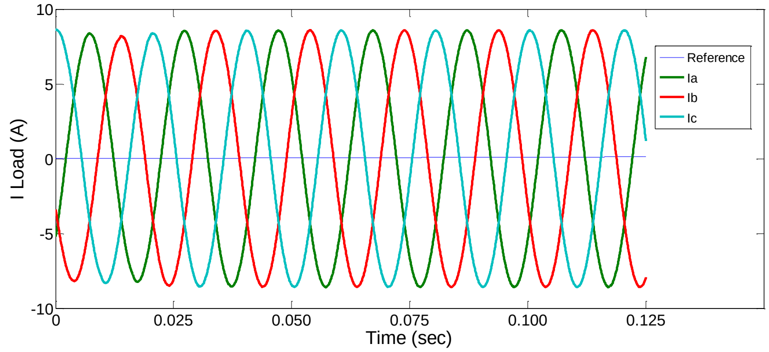

Figure Error! No text of specified style in document.. **Output Current Waveform at Load**

The output current waveform at load shown in figure 4 is the rectified and modified form of the current waveform obtained at the source and at the point of common coupling. The current harmonics are minimized with the help of D-STATCOM. The output voltage and output current waveforms at the point of common coupling are shown in figure 5 and figure 6.

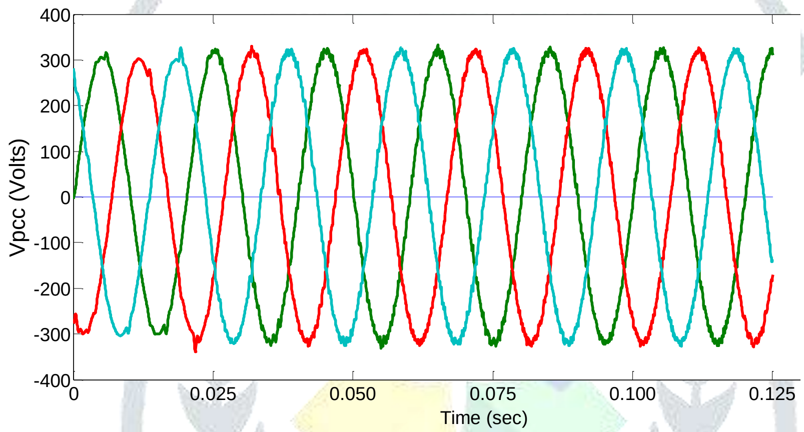

Figure 5. Voltage Waveform at PCC

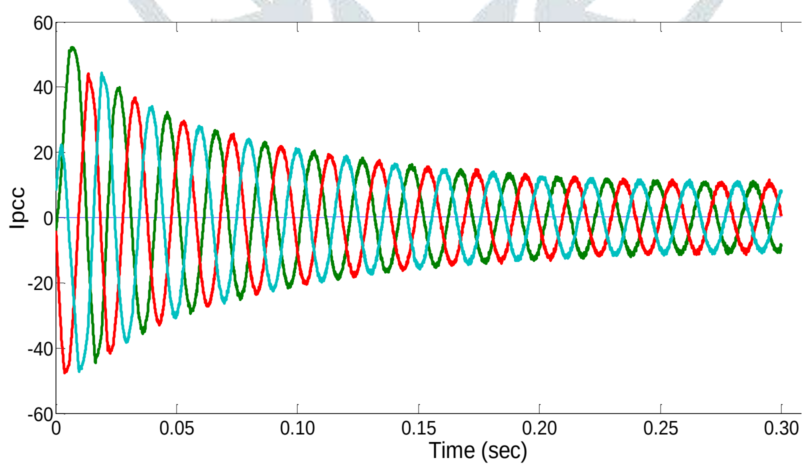

Figure 6. Current Waveform at PCC

It is also observed that the output voltage waveform contains very less harmonics. It is calculated by FFT analysis. The input signal is taken as voltage at fundamental frequency of 50Hz is 312.5 V generates the THD of 1.68%.

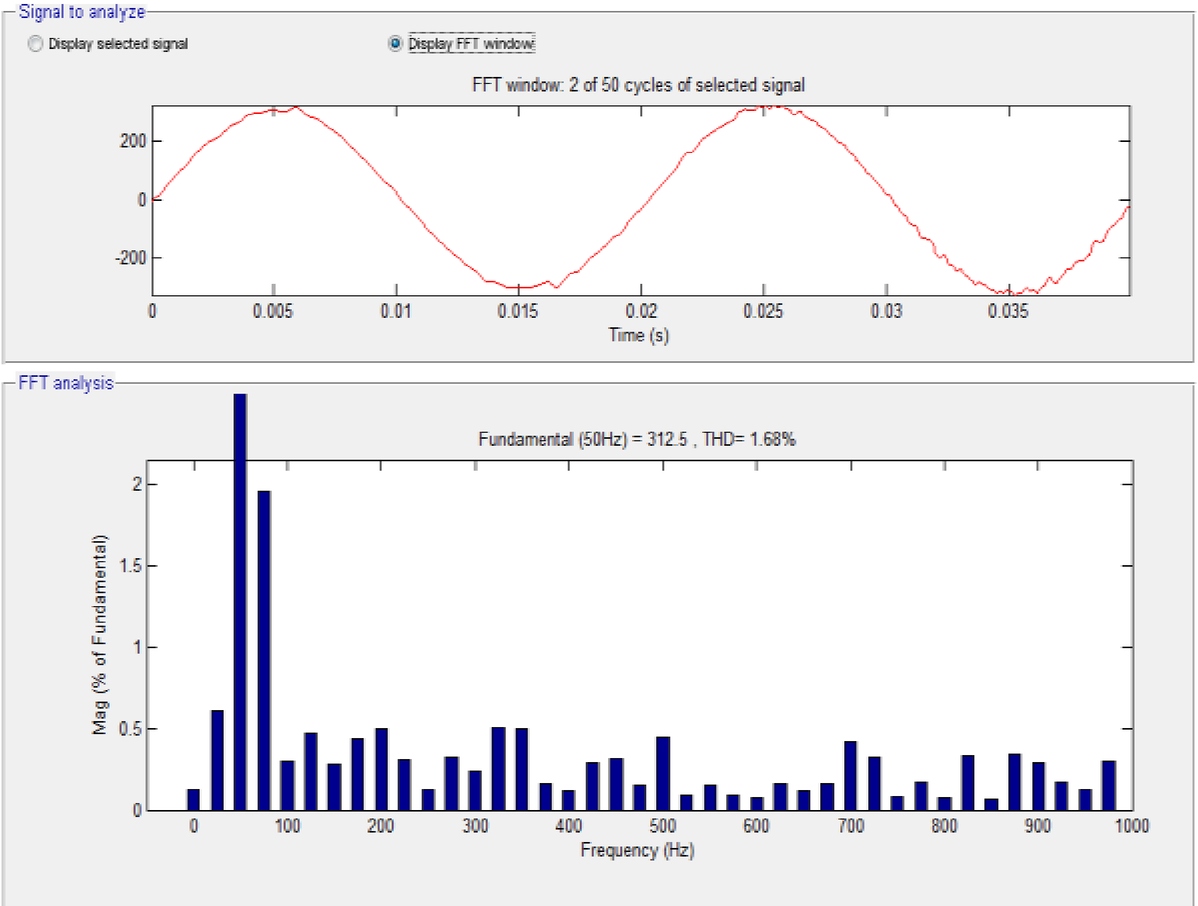

Figure 7. THD Response of the Output Signal for 2 cycles of Time Period

VIII. CONCLUSION

Based on the research work done D-STATCOM modeling is evaluated. STATCOM which is utilized for localized central placement is sub-integrated by distributing with lower capacity. D-STATCOM effect in power networking and power quality analysis were evaluated. This is new technology whose implementation and impact to real time system will change the control of systems, meanwhile research on simulation were going on to know each impact of the controller.

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