DSTATCOM for Harmonic Mitigation in Distribution Lines using Two-Level Inverter

Vidya M., P. Pramila, A. M. Nagaraj

Abstract: Distribution systems have been facing serious problems of harmonics load current mainly due to advancement in power electronic based and other non-linear loads. The DSTATCOM has been widely used to mitigate the load current harmonics problems in distribution system. The power quality improvement is one of the major problems when the distribution side load increases with non-linear loads like electric vehicles, laptops, PCs etc., There are some power quality mitigation technique available at the load side where the electronic chargers works with unity power factor (UPC) control. But many DC loads are connected without the UPC. So, it is a need for a device which corrects the real and reactive power at the distribution level. The DSTATCOM is connected to the Indian distribution system with 415V, 50Hz. In this paper the linear loads and nonlinear loads are coupled to the system and analysis with DSTATCOM and without DSTATCOM cases are presented.

Keywords: DSTATCOM, Distribution systems, Unity power factor control, non-linear loads.

I. INTRODUCTION

Distribution system now days are facing several power quality problems like poor power factor, poor voltage regulation, harmonics current burden, unbalanced loading, neutral current etc. The usage of semiconductor devices in recent DC devices increases the power quality problems. For any loading condition the power quality has to be good [1]. Even the source values changes and load changes the power quality has to be consistent. The power quality issues due to source side changes are voltage sag and swell, At the load side current harmonics and flicker problems are the major problems. Harmonics current is mainly because of use of non-linear nature of load and poor power factor and poor voltage regulation is mainly due to the inductive load and line drop respectively. Many Custom Power Devices like DVR, UPQC are proposed for mitigating the power quality problems in distribution system. Distribution Static Compensator is shunt connected device which is able to mitigate load current based power quality problems. it injects compensating current such that load current based power quality problems like voltage sag, voltage swell, unbalance.

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loading, poor power factor, poor voltage regulation, harmonics etc. can be mitigated using the DSTATCOM. The multilevel inverter-based FACTs devices are used for reduction of the passive elements to get better power quality [2,3]. Here the two-level inverter is used as the DSTATCOM to mitigate the power quality problems like harmonics and the power factor. Hence the classical two-level inverter is used to improve the power quality in the distribution side of the power system.

II. BASIC OPERATING PRINCIPLE

The DSTATCOM single line illustration is shown in figure 2.1. The inverter which has the two-level switches is connected with the capacitor at DC side. The AC side of the inverter is connected with the isolating transformer and leakage inductance of the transformer.
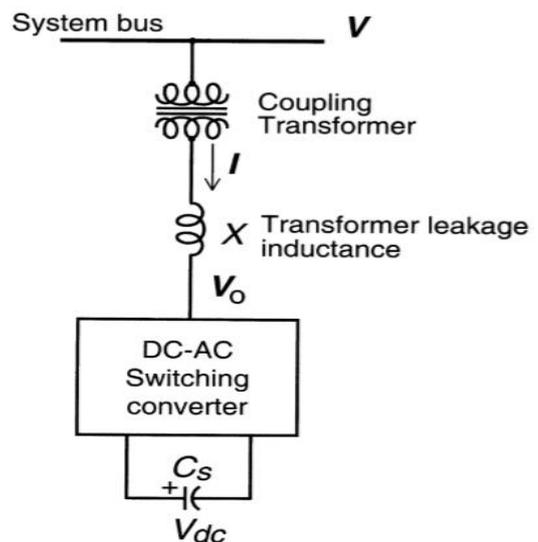

Fig 2.1 Single Line illustration of DSTATCOM

The inverter is controlled as such the phase shift of the injected current angle changes. This change creates the changes in the reactive power. If there is lag of current with respect to voltage, then the DSTATCOM works as the inductive mode of operation. If the current leads than the voltage then it works as the capacitive injection mode. Most of the power system is loaded with inductive so the DSTATCOM generally works like a capacitor where the capacitance can be varied precise and maintain the voltage. To make sure the operation of the DSTATCOM the DQ0 based control technique is used. Here the D- takes care of real part of the power and Q takes care of the reactive part. The energy stored in the capacitor is used in the power system to compensate the harmonics.

III. CONVERTER SCHEMES USED FOR REACTIVE POWER GENERATION.

The 3.1 shows the reactive power converters used in practical. It can be single phase or three phase two level inverter or three phase three level. The converters are made with MOSFETS and the two level three phase converter is used in this paper.
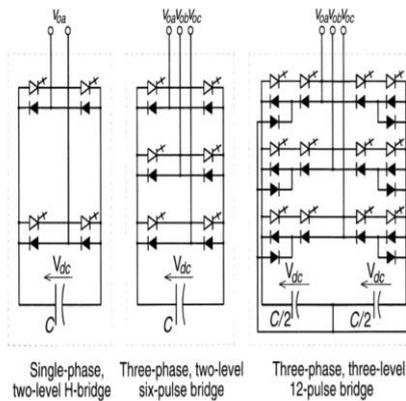

Fig:3.1 elementary converter schemes used for reactive power generation.

There is a requirement of pulse width modulation in the two-level inverter. Here sinusoidal pulse width modulation (SPWM) is used to switch the MOSFET. The sine wave is generated from the DQ0 control unit and the controlled DQ is given to DQ0-ABC converter to produce the modulating waveform. This modulating waveform is given to saw tooth comparison and the pulses are created. These pulses are given to MOSFET. The sine wave used for modulation is the output signal of controller.

IV. SIMULATION AND RESULTS

Devices	Parameters	Values
Grid	Voltage in V	415
	Frequency in Hz	50
	Power in MVA	100kVA
linear Load	Real power in W	5000
	Reactive power VA	3000
Non-linear load (rectifier)	R in ohms	20
	L in H	0.1
	C in F	500u
Line parameters	R in ohms	0.001
	X in mH	0.05
DSTATCOM	power rating	50kVA

Table:4.1 Parameters used for simulation

The test system is constructed in MATLAB with 415 V and 50Hz system. The base power of the system is 100kVA. The transmission line parameters are taken as $0.001\,\Omega$. The reactance of the system is $0.05\,mH$. The linear load of

5000W and 3000 VA are used. And as nonlinear load the rectifier bridge for three phases is used with load of 20Ω.
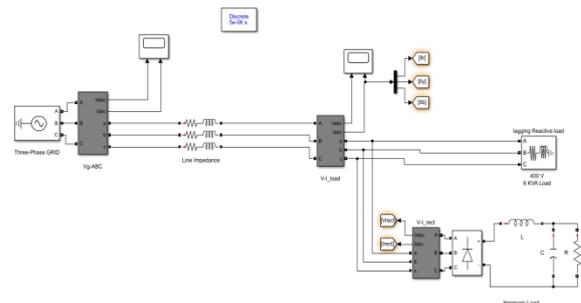
(i)   Without DSTATCOM

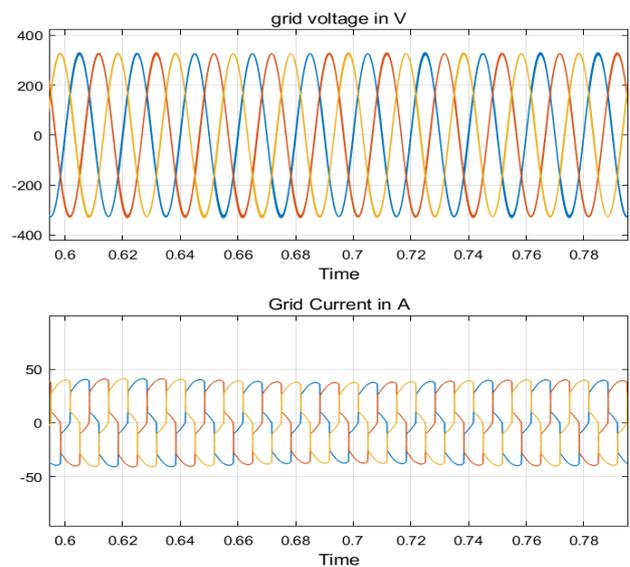**Fig:4.1 Without DSTATCOM (test system)**

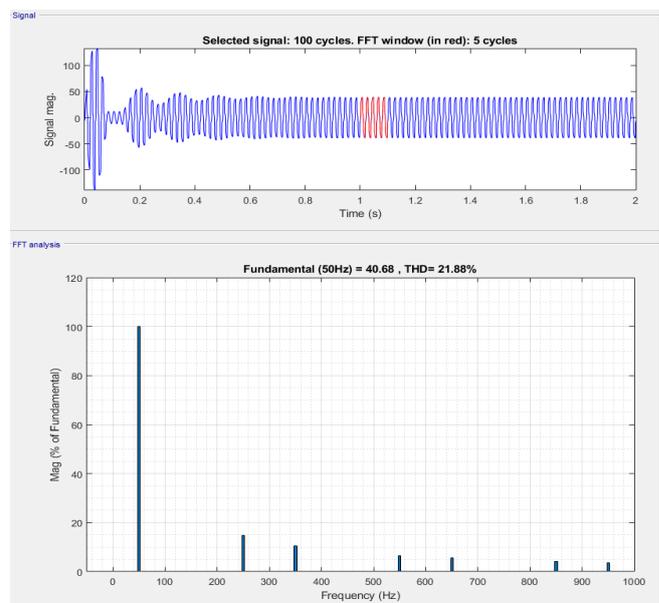**Fig:4.2 Grid voltage and Current**

Fig:4.3 Total harmonic distortion (THD) for without DSTATCOM

This problem can be mitigated by using the DSTATCOM.
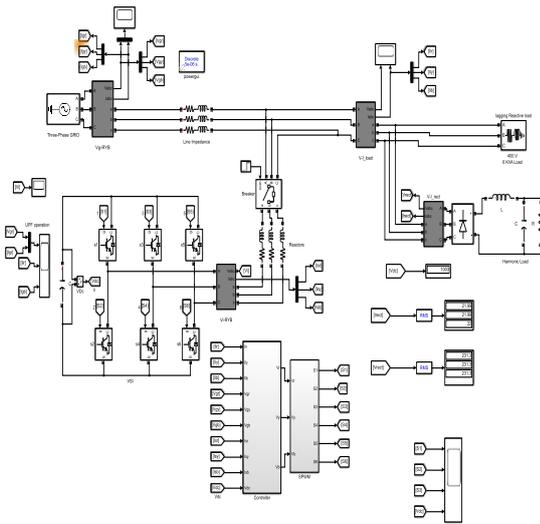
(ii)   with dstatcom using 2-level inverter

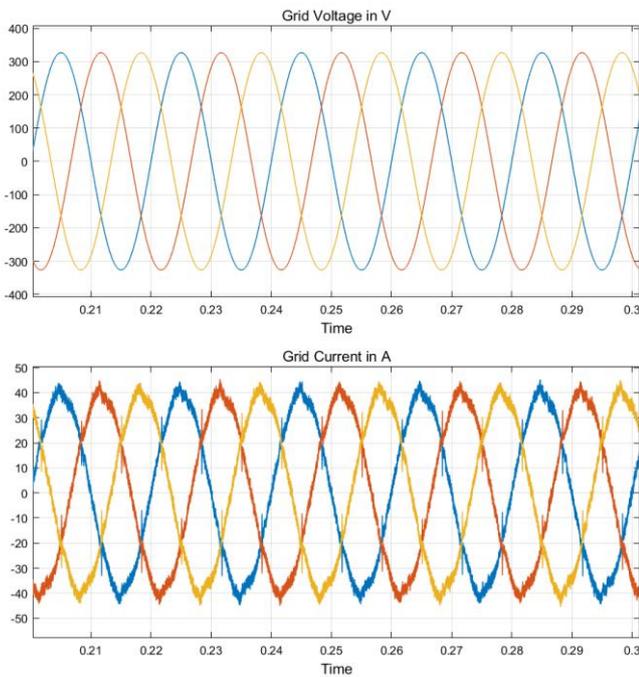**Fig:4.4 With 2-level inverter DSTATCOM (test system)**

Fig:4.5 Grid Voltage and Current with DSTATCOM

Table: 4.2   Comparison Of Frequency And Thd With And Without Dstatcom

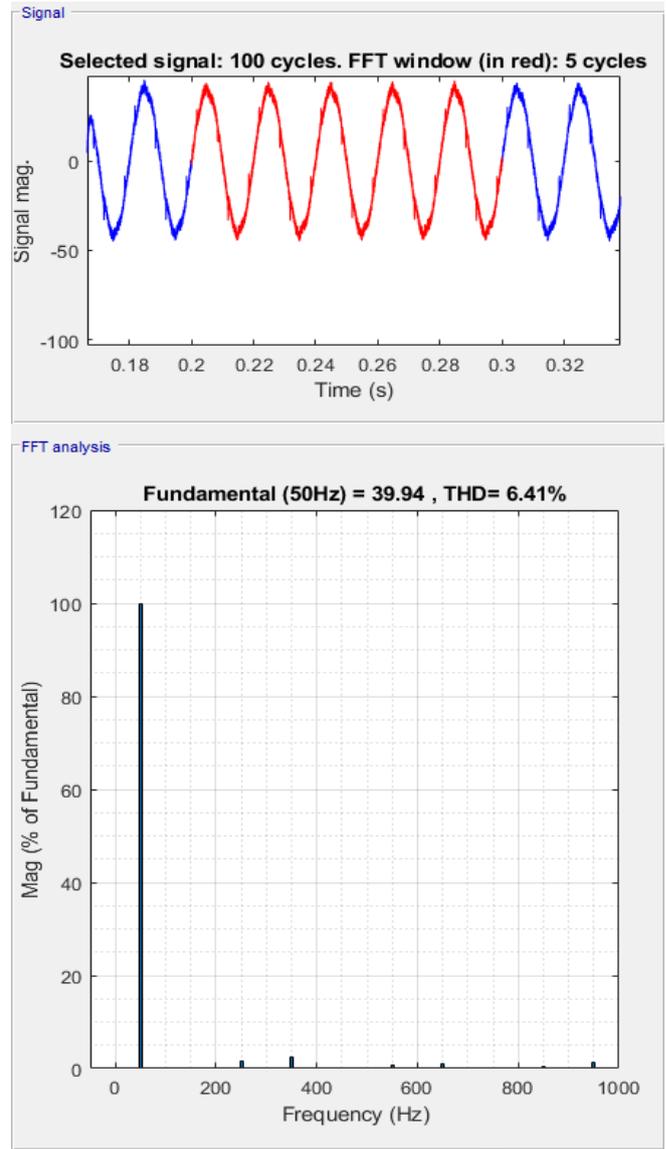| Parameters	Without DSTATCOM	With DSTATCOM
Fundamental Frequency(50Hz)	40.68	39.94
THD	21.88%	6.41%

fig:4.6 total harmonic distortion (thd) for with dstatcom

V. CONCLUSION

Custom Power (CP) devices can be used, at reasonable cost, to provide high power quality and improved power service. One such device used in this work is the DSTATCOM. These Custom Power devices provide solutions to power quality at the medium voltage distribution network level. This paper presents the   modeling and simulation of DSTATCOM used in the distribution lines. The Indian system of 415 V, 50Hz system is constructed and the non-linear loads are connected to it. It produces a 21.88% of harmonics which is out of the IEEE standards. The DSTATCOM is placed using the 2-level inverter. This DSTATCOM changed the waveform shape of the current and the required compensation is done. It gives harmonics of 6.41%. Further the work can be extended using three-level inverter to get better results as compared to two-level inverter.

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