

# POWER QUALITY ENHANCEMENT BY USING CASCADED H BRIDGE MULTILEVEL INVERTER BASED DSTATCOM

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**Abstract** - In power system reactive power compensation is important concern as V-Q profile are interrelated. This paper emphasize on compensation of reactive power and harmonics. The system with CHB inverter is more robust and has less number of switches which in turn reduces switching losses. In this paper synchronous reference frame theory is used for reference signal generation and capacitor DC voltage is regulated by using PI controller. The gate pulses to Inverter Bridge are given by LSPWM technique. In this paper DSTATCOM is designed for 11KV distribution system by using CHB inverter for compensation of reactive power and harmonics. The results are obtained through MATLAB. Comparative analysis in terms of THD is made for 3 and 5 level inverter.

**Key Words:** DSTATCOM, Synchronous reference frame theory (SRF), level shifted pulse width modulation (LSPWM), cascaded H bridge multilevel inverter (CHB)

## 1. INTRODUCTION

In modern power system power quality is very important issue related to THD. For improving power quality in terms of THD and compensating reactive power series or shunt compensators are used. Simple or multilevel inverter can be used for meeting these objectives. Simple inverter produces only three voltages Levels while multiple voltage levels can be achieved by using multilevel inverter which produces less harmonic distortions [2]. By increasing number of voltage levels of inverter output waveform become more sinusoidal and which thus results in reduced THD. Only the constraint is as number of voltage levels of inverter are increased, the number of bridges in series needs to be increased.

The multilevel inverter is categorized as cascaded H Bridge, Diode clamped and Flying capacitor inverter [5]. The CHB inverters are mostly used due to their advantages like simplicity, low switching losses and reduced number of switches. The STATCOM used at distribution side is known as DSTATCOM. By varying magnitude and phase angle of inverter voltage reactive power can be exchanged.

## 2. DESIGN OF DSTATCOM

### 2.1 Principle of DSTATCOM

DSTATCOM is a shunt-connected custom power device designed for power factor correction, current harmonics filtering and load balancing. It can also be used for voltage regulation at a distribution bus. It is often referred to as a shunt or parallel active power filter. It consists of a voltage or a current source PWM converter. It operates as a current controlled voltage source and compensates current harmonics by injecting the harmonic components generated by the load but phase shifted by 180 degrees. With an appropriate control scheme, the DSTATCOM can also compensate for poor load power factor.

This paper focuses on DSTATCOM based on CHB inverter where dc energy from renewable sources or batteries converted into ac energy. Fig1 shows two level voltage source converter with dc energy source is connected in shunt to transmission line by using coupling transformer. Three phase ac voltages are obtained from dc voltage across storage device by using VSC. By varying magnitude and phase angle of inverter voltage reactive power can be exchanged between DSTATCOM and ac system. Such type of arrangement provides voltage regulation, compensation of reactive power, correction of power factor elimination of current harmonics [1].

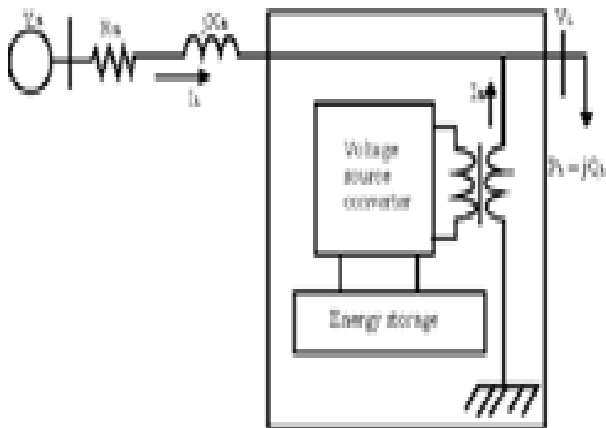


Fig -1: Schematic diagram of DSTATCOM

### 2.2 Cascaded H Bridge multilevel inverter

Multilevel converters have types as diode clamped, flying capacitor and cascaded multilevel inverter [2]. But the CHB inverter is used mostly due to advantages like simplicity, modularity, low switches and low switching losses. Mostly IGBT switches are used to achieve high switching efficiency.

With CHB inverter we get multiple voltage levels. The levels of voltages depend basically on number of bridges connected in series. The numbers of output voltage levels of CHB are  $2n+1$ , where  $n$  is number of H bridges connected in series. Thus with single CHB inverter having  $n=1$ , three levels of voltages are produced as  $+V_{dc}$ ,  $0$  and  $-V_{dc}$ . With two H-bridges connected in series as shown in fig. 3, it produces five levels of output voltage as  $+2V_{dc}$ ,  $+V_{dc}$ ,  $0$ ,  $-V_{dc}$ ,  $-2V_{dc}$ . The switching order of various switches under such configuration is mentioned in table-2.

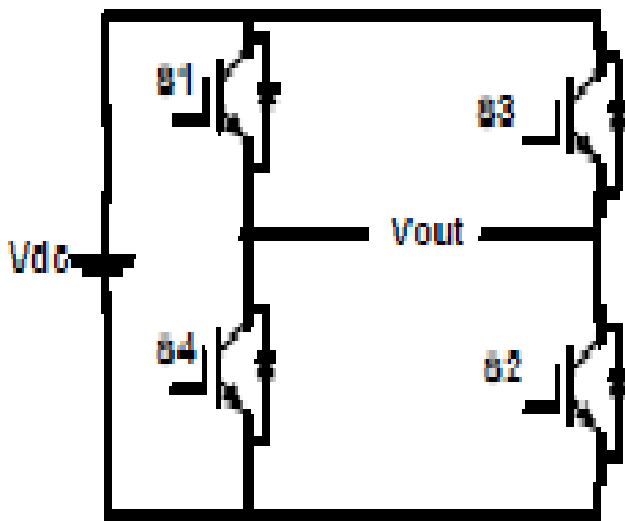


Fig -2: Single Bridge inverter

The schematic diagram of simple bridge inverter is shown in fig.2. The switching state of various switches is presented in table- 1. The 1 and 0 represents off and on state of switch respectively.

Table -1: Switching table for single bridge inverter

Voltage level	S1	S2	S3	S4
$V_{dc}$	1	1	0	0
0	0	1	0	1
$-V_{dc}$	0	0	1	1

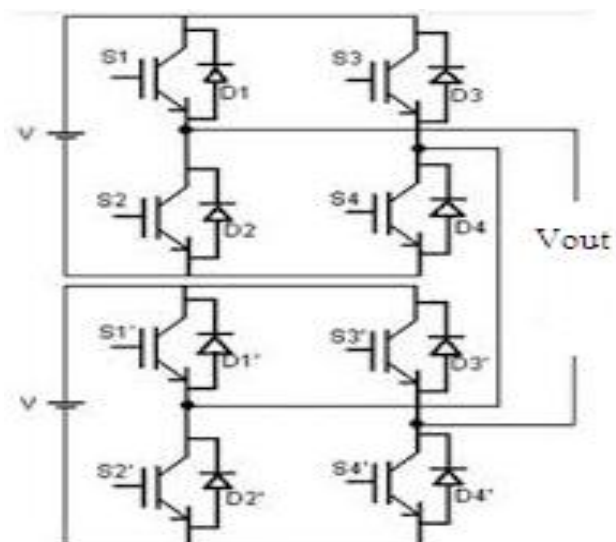


Fig -3: Five level CHB inverter

Table -2: Switching table for 5 level CHB inverter

Voltage level	S1	S2	S3	S4	S5	S6	S7	S8
$2V_{dc}$	1	1	0	0	1	1	0	0
$V_{dc}$	1	1	0	0	0	0	0	0
0	0	1	0	1	0	1	0	1
$-V_{dc}$	0	0	1	1	0	0	0	0
$-2V_{dc}$	0	0	1	1	0	0	1	1



### 3. MATLAB MODELING AND RESULTS

The system parameters considered for simulation study are as follows

Table -3: System parameters

System parameter	Rating
Source voltage	11 kV
Frequency	50Hz
DC bus capacitance	1550e-6F
Inverter series inductance	10 mH
Source resistance	0.1 ohm
Source inductance	0.9 mH
Load resistance	60 ohms
Load inductance	30mH

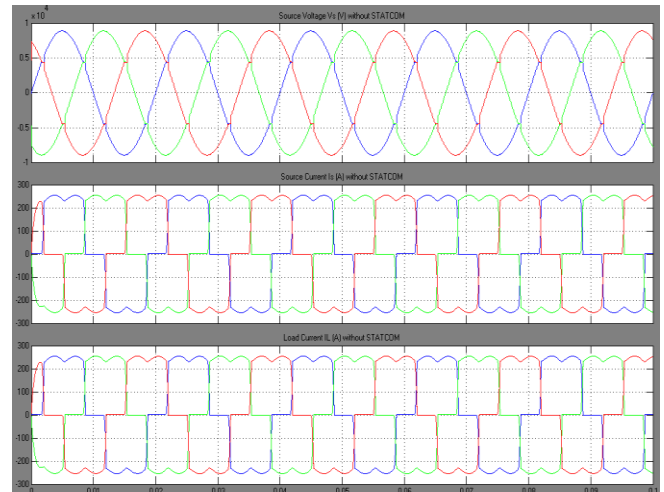


Fig -7: Source voltage, current and load current without DSTATCOM

The harmonic spectrum of Phase-A source current without DSTATCOM is presented in fig.8. The THD of source current without DSTATCOM is observed as 28.25%.

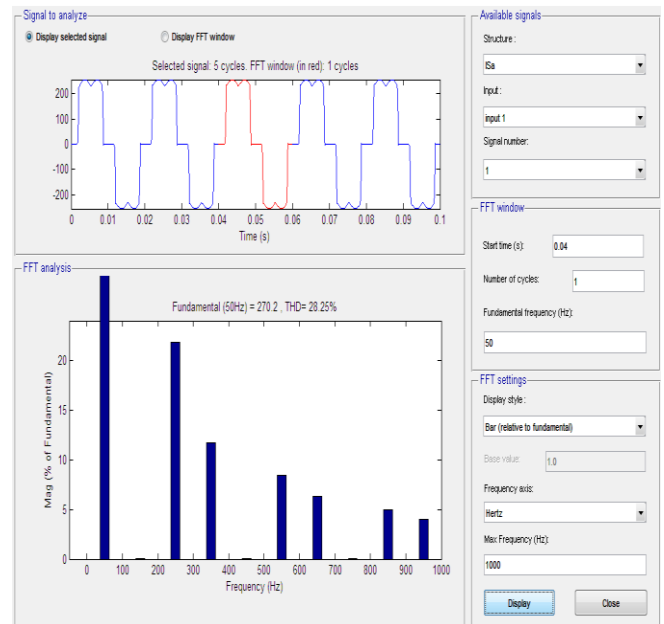


Fig -8: Harmonic spectrum of Phase-A Source current without DSTATCOM

#### 3.1 Results Obtained Without DSTATCOM

The Matlab model for basic power system without any compensating device is shown in Fig.6.

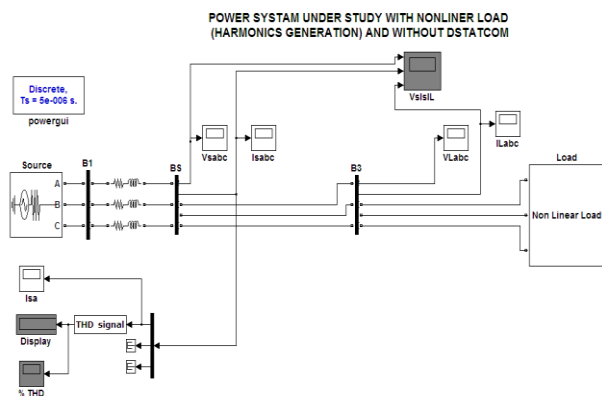


Fig -6: Basic uncompensated power system under study with a nonlinear load

Fig.7 shows source voltage, current and load current without DSTATCOM. It seems that load current and source current both are same and non sinusoidal without DSTATCOM.

#### 3.2 Results Obtained with DSTATCOM

Simulink model of power system under study compensated with multilevel CHB based inverter with LSPWM using SRF based method is represented in fig.9.

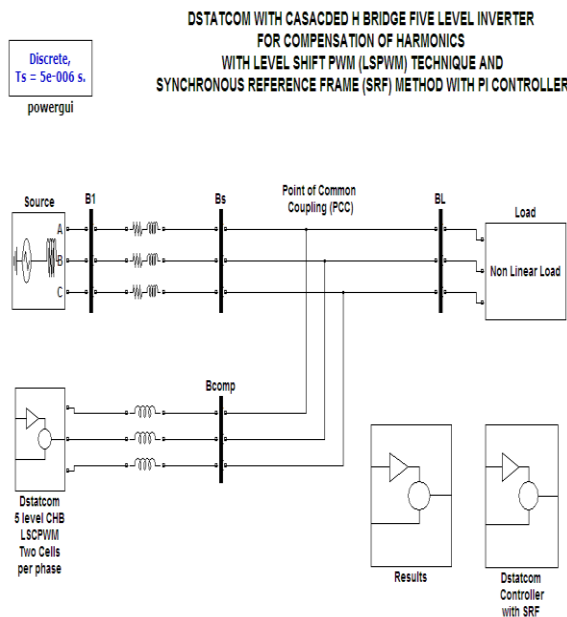


Fig -9: Simulink model of power system with DSTATCOM

### 3.2.1 Results of Three Level CHB inverter based DSTATCOM

Phase A voltage of Three level LSPWM inverter is shown in fig.10.

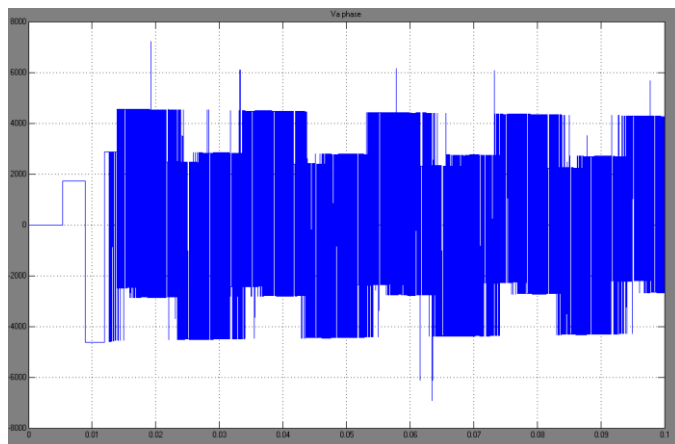


Fig -10: Three level output voltage of inverter

Under this case source voltage, current and load current with three level CHB inverter with LSPWM based DSTATCOM using SRF are shown in fig.11. With the help of DSTATCOM source current becomes sinusoidal although load current is non sinusoidal.

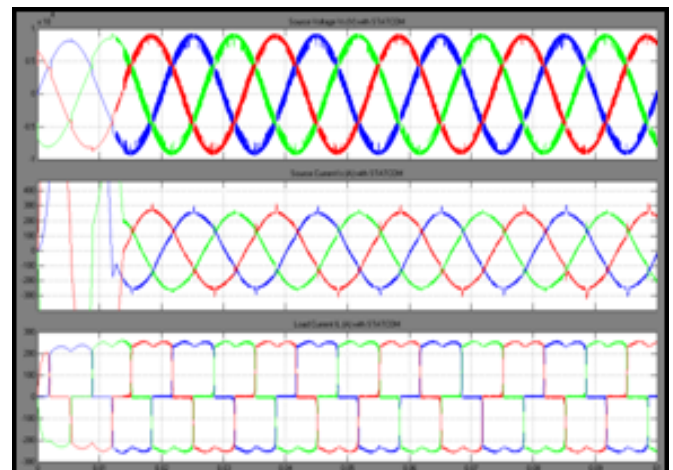


Fig -11: Source voltage, current and load current with three level CHB inverter with LSPWM based DSTATCOM using SRF

Harmonic spectrum analysis of Phase-A Source current with three level CHB inverter with PSPWM based DSTATCOM using SRF method is shown in fig.12. The THD of source current with DSTATCOM is reduced to 4.73%.

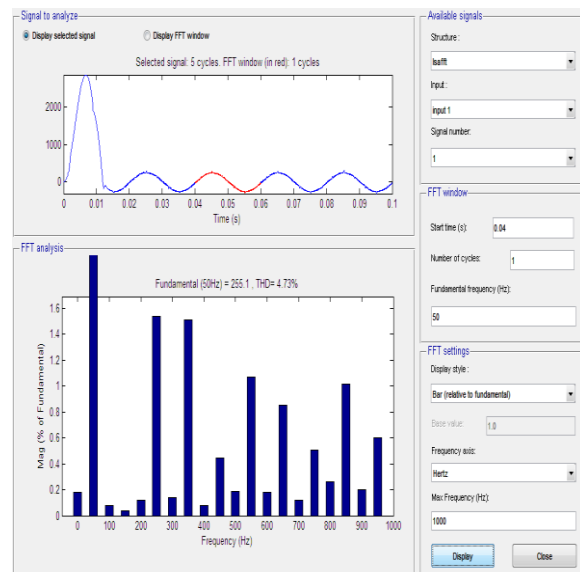


Fig -12: Harmonic spectrum analysis of Phase-A Source current with three level CHB inverter with PSPWM based DSTATCOM using SRF

### 3.2.2 Results of Five Level CHB inverter based DSTATCOM

The voltage of Phase A of Five level LSPWM inverter is represented in fig. 13. It shows five step output.

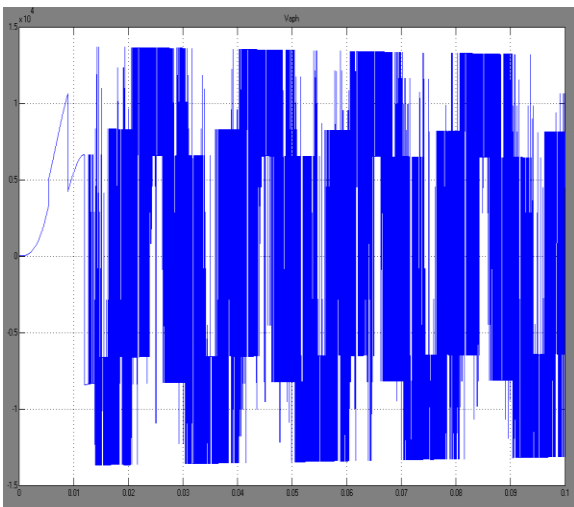


Fig -13: Five level output voltage of inverter.

Fig -14. Shows Source voltage, current and load current with three level CHB inverter with LSPWM based DSTATCOM using SRF method. In this case the source current is found more sinusoidal as compared to that with three level inverter topology.

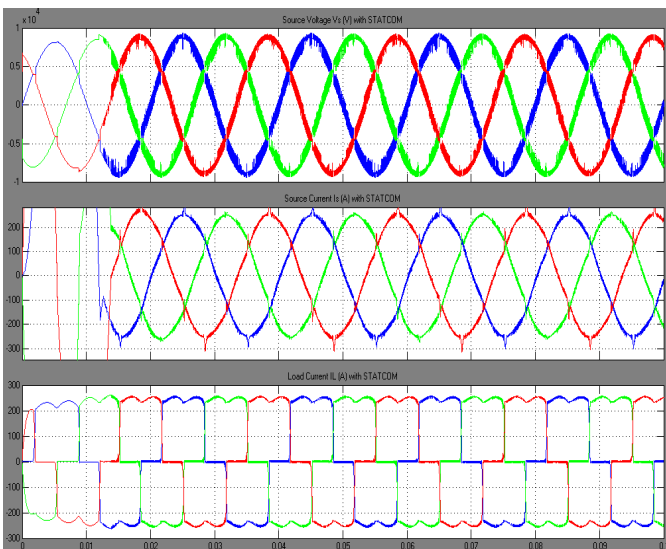


Fig -14: Source voltage, current and load current with five level CHB inverter with LSPWM based DSTATCOM using SRF Method

Harmonic spectrum analysis of Phase-A Source current with five level CHB inverter with PSPWM based DSTATCOM using SRF method is shown in fig.15. The THD of source current with five level inverter is further reduced to 4.68%.

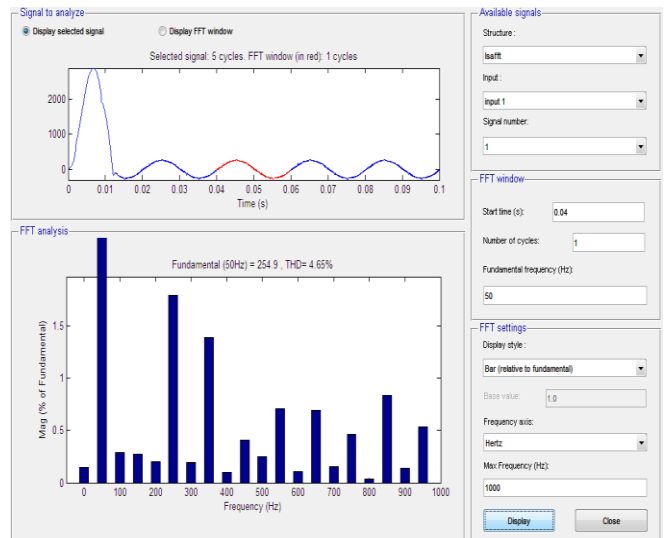


Fig -15: Harmonic spectrum analysis of Phase-A Source current with five level CHB inverter with PSPWM based DSTATCOM using SRF

For this case the source current and voltage both are found to be in phase, so power factor is unity.

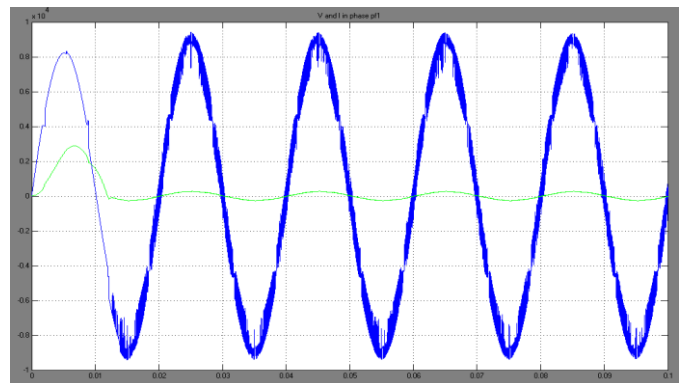


Fig -16: Phase A source voltage and current

Meanwhile the DC side voltage of capacitor is regulated to 11KV as shown in fig.17.

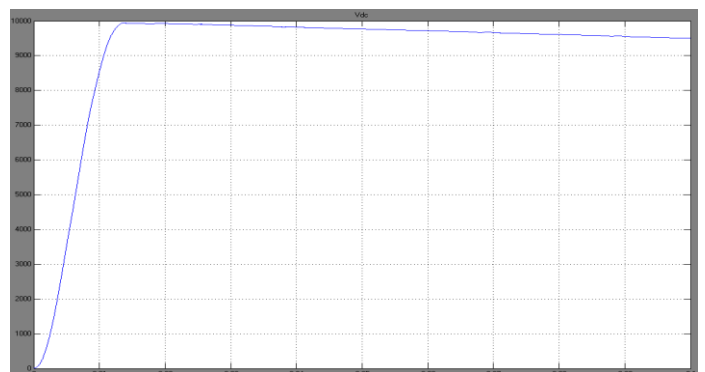


Fig -17: DC bus voltage.

A DSTATCOM with three level and five level CHB inverter is investigated and comparison as follows-

Table -4: Comparison of three level and five level multilevel inverter using LSPWM technique from simulation results for non linear load for considered power system.

Method	Level	% THD	Fundamental
SRF	Three	4.73	255.1
	Five	4.65	254.9

#### 4. CONCLUSION

In this paper comparison of three level and five level multilevel inverter is presented. The reference current is generated by using SRF method which considers abc to dq0 transformation. DC bus voltage is regulated to 11KV by using PI controller. The percentage of total harmonic distortion is reduced with increase in inverter levels. Further the system can be examined for seven level topology.

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