# D-STATCOM based five-level Cascade H-Bridge multilevel inverter for Power Quality Improvement

[1]Ezhilmaran.M, [2]Reshma.D, [3]Aishwarya.K, [4]Priya Dharshini.M
[1]Associate Professor, [2,3,4]UG Scholar,
[1,2,3,4]Chennai Institute of Technology, Chennai, Tamil Nadu, India.
[1]suryapark2002@gmail.com, [2]reshmadaniel98@gmail.com, [3]aishwarya.malakannan@gmail.com,[4]priyamahesh30.pd@gmail.com

***Abstract*—** The custom power device (i.e) Distribution Static Compensator (D-STATCOM) is used to reduce harmonics in distribution system. The shunt type active power filter the VSC is developed with multi level cascade H-Bridge inverter is a cascaded multilevel inverter consists of a series of single phase full bridge inverter units. The general function of this multilevel inverter is to synthesize a desired voltage from several separate DC sources, which may be obtained from batteries, fuel cells or solar cells. Each separate DC source is connected to a full bridge inverter. The cascaded multilevel inverter does not require any voltage clamping diodes or voltage balancing capacitors like other two topologies.

***Index Terms*—Power quality, Cascade H –Bridge.**

## I. INTRODUCTION

The power quality issues are more serious in electronic based systems[1]. The level of harmonics and reactive power demand are popular parameters that specify the degree of distortion and reactive power demand at a particular bus of the utility [2]. The harmonic resonance is one of the most common problems reported in low- and medium-level distribution systems. Power converter-based custom power devices (CPDs) are useful for the reduction of power quality problems. The performance of any custom power device depends very much upon the control algorithm used for the reference current estimation and gating pulse generation scheme .A three phase ac source is feeding to the linear load/non linear loads. A voltage source converter (VSC)-based D-STATCOM is connected to a three phase ac mains feeding three phase loads with internal grid impedance. The current transformer and the potential transformer are used to sense the voltage and current from the three phase line. A VSC based D-STATCOM consist of MLI cascade H-bridge inverter.

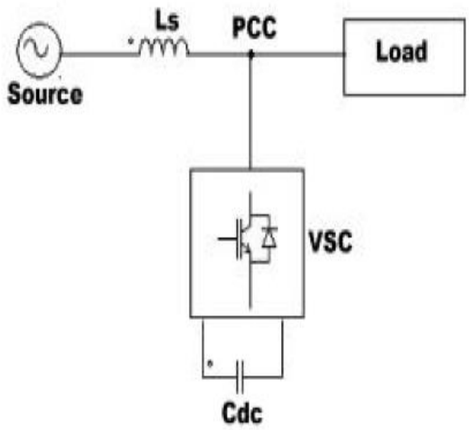



Fig.1. Schematic diagram of D-STATCOM

## II. CASCADE H-BRIDGE MULTILEVEL INVERTER

A three-phase structure of a five-level cascaded inverter is illustrated in Figure 2. The multilevel inverter using cascaded-inverter with separate dc sources (SDCSs) synthesize a favorable voltage from several independent sources of dc voltages, which may be achieved from batteries, solar cells and fuel cells [6]. This structure recently has become very widespread in ac power supply and adjustable speed drive applications the output of each cell will have three levels +Vdc , 0 and −Vdc that obtained by connecting the dc source to the ac output by different combinations of the four switches S1 , S2 , S3 and S4 . To obtain +Vdc , switches S1 and S4 are turned on, whereas −Vdc can be obtained by turning on switches S2 and S4 . By turning on S1 and S2 or S3 and S4 , the output voltage is 0. The output voltage is the sum of the voltage that is generated by each cell. The numbers of output voltage levels are 2( 1) m + where m is the number of cells.

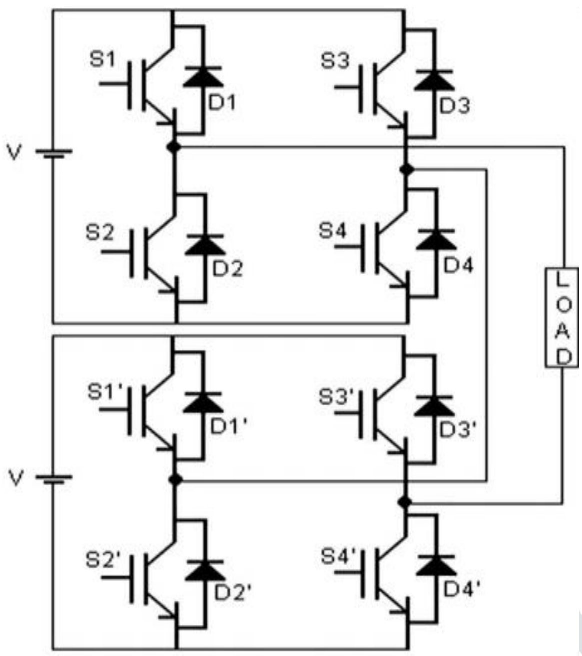



Fig.2. Five level cascade H-bridge inverter structure

Fig.2. shows cascaded multilevel inverter consists of a series of three phase full bridge inverter units[8]. The general function of this multilevel inverter is to synthesize a desired voltage from several separate DC sources, which may be obtained from batteries, fuel cells or solar cells. Each separate DC source is connected to a full bridge inverter [9][10]. The cascaded multilevel inverter does not require any voltage clamping diodes or voltage balancing capacitors like other two topologies.

TABLE I
Component requirements for m-level cascade H-bridge inverter

| **S.No** | **m-Level Cascade H-Bridge** | ***Number of elements*** | ***Number of elements for three phase*** |
|---|---|---|---|
| 1 | DC bus capacitors | (m-1)/2 | 6 |
| 2 | Main diodes | (m-1)*6 | 24 |
| 3 | Main switches | ( m-1)*6 | 24 |
| 4 | Clamping diodes | 0 | 0 |
| 5 | Clamping capacitors | 0 | 0 |

## III. MODULATION STRATEGY

The modulation schemes for the multilevel CHB inverters can be generally assortment into carrier based modulation, space vector modulation and staircase modulation with selective harmonic elimination [9]. The carrier-based modulation schemes for multilevel inverters are classified to phase-shifted and level shifted modulations. In this paper, the inverter switches are controlled by pulse width modulation strategy employing phase shifted carriers (PSPWM). Multilevel inverter with m voltage levels needs m−1 triangular carriers. In the phase-shifted multicarrier modulation, all the triangular carriers have the equal frequency and the peak-peak amplitude with the phase shift between any two adjacent carrier waves given by: 360 1 cr m ϕ = − D (2) The frequency modulation index mf is given by: m f /m f = cr m (3) where cr f and mf respectively mention to carrier signal frequency and fundamental signal frequency. The frequency of prevalent harmonic in the inverter output voltage is given by [10] , ( 1) sw inv sw dev f mf = − × (4) where sw, dev f represents the device switching frequency. The modulated signal V-control is compared with a phase shifted triangular signals in order to generate the switching signals. Figure 3 shows waveforms of carrier, modulating and command signals using phase shifted PWM method. The main parameters of the phase shifted PWM scheme are the amplitude modulation index of signal, and the frequency modulation index of the triangular signal [11].

**IV SIMULATION RESULT**

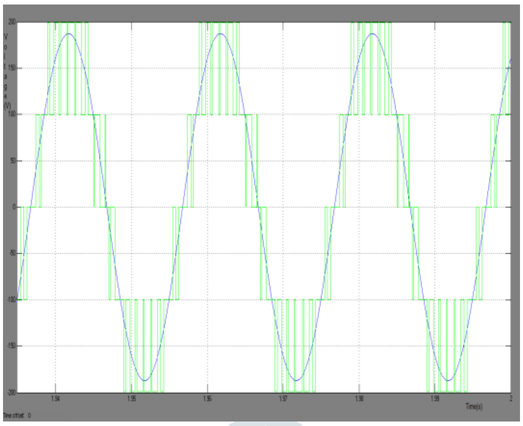


Fig.3. Voltage and current waveform for MLI.

The simulink model for compensated system with 415V, 50 Hz three phase source is connected to a three phase load. The BP control algorithm is used here for injecting the current for compensating the voltage by which the reactive power compensation is done. The load voltage is 520V and load current is 25A.

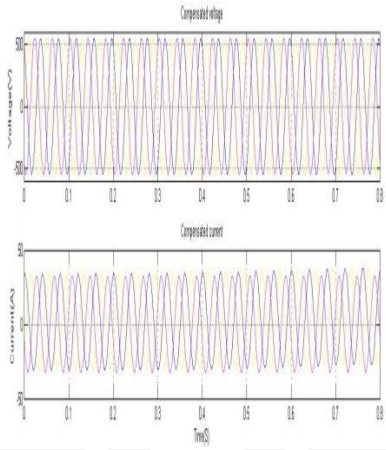
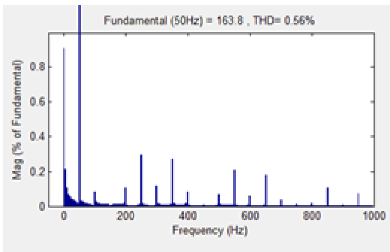
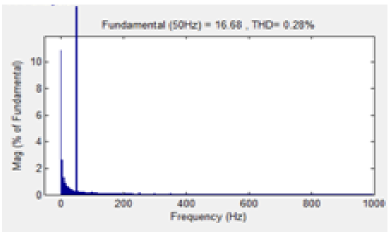


Fig.4. Voltage and current waveform for compensated system.

The Fig.4.shows the results of three phase source voltage and current waveform for compensated system. The source voltage is 415V and 50Hz and the waveforms here is shown. The Fig.5(a). shows the total harmonic voltage distortion display at the output side for compensated system.The load voltage is taken as the input. It displays the one cycle of load current in which the distortions obtained is as 0.56% at the fundamental frequency.Fig.6(b) shows the total harmonic current distortion display at the output side for compensated system. It displays the one cycle of load current in which the distortions obtained is as 0.28% at the fundamental frequency. The power factor for compensated system using the BP control algorithm at the source side is 0.956. Fig.6 shows the wave form of real and reactive power.




(a)




(b)

Fig.5. Harmonic analysis (a) voltage order and (b) current order for compensated system

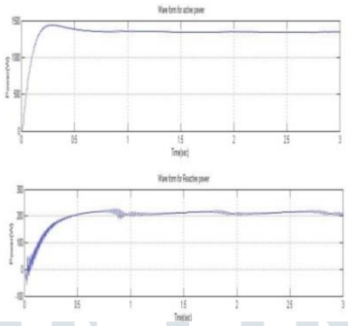


Fig.6. Wave form for real and reactive power

TABLE II
TOTAL HARMONIC DISTORTION IN PERCENTAGE

| **Entity** | ***Without compensation*** | ***With compensation using MLI*** |
|---|---|---|
| $i_{sa}$ | 34.24 | 0.28 |
| $i_{sb}$ | 34.11 | 0.14 |
| $i_{sc}$ | 35.14 | 0.20 |
| $v_{sa}$ | 8.21 | 0.56 |
| $v_{sb}$ | 8.25 | 0.59 |
| $v_{sc}$ | 8.27 | 0.55 |

## IV.CONCLUSION

A VSC based D-STATCOM has been accepted as the most preferred solution for power quality improvement. The multilevel based D-STATCOM is used for switching purpose. It is able to extract the reference source currents in varying load conditions. The dc bus voltage of the DSTATCOM has also been regulated to the rated value without any overshoot or undershoots during the load variation. The THD values for the uncompensated system are high when compared to the compensated system. Thus, the THD of the supply current below the limits specified by the IEEE-519 standard. Simulated and test results have verified the effectiveness of this algorithm.

REFERENCES

[1] K. R. Padiyar, FACTS Controllers in Power Transmission and Distribu- tion. New Delhi, India: New Age Int., 2008.
[2] T. L. Lee and S. H. Hu, "Discrete frequency-tuning active filter to suppress harmonic resonances of closed-loop distribution power systems," IEEE Trans. Power Electron., vol. 26, no. 1, pp. 137–148, Jan. 2011.
[3] S. Rahmani, N. Mendalek, and K. Al-Haddad, "Experimental design of a nonlinear control technique for three-phase shunt active power filter," IEEE Trans. Ind. Electron., vol. 57, no. 10, pp. 3364–3375, Oct. 2010.
[4] T.-L. Lee, S.-H. Hu, and Y.-H. Chan, "DSTATCOM with positive- sequence admittance and negative-sequence conductance to mitigate voltage fluctuations in high-level penetration of distributed generation systems," IEEE Trans. Ind. Electron., vol. 60, no. 4, pp. 1417–1428, Apr. 2013.
[5] J.-C. Wu, H. L. Jou, Y. T. Feng, W. P. Hsu, M. S. Huang, and W. J. Hou, "Novel circuit topology for three-phase active power filter," IEEE Trans. Power Del., vol. 22, no. 1, pp. 444–449, Jan. 2007.
[6] S. Cong and Y. Liang, "PID-like neural network nonlinear adaptive con- trol for uncertain multivariable motion control systems," IEEE Trans. Ind. Electron., vol. 56, no. 10, pp. 3872–3879, Oct. 2009.
[7] J. C. Wu and S. J. Huang, "Design and operations of cascaded active power filters for the reduction of harmonic distortion in a power system," Proc. Inst. Elect. Eng., vol. 146, no. 2, pp. 193–199, 1999.
[8] P. Kumar and A. Mahajan, "Soft computing techniques for the control of an active power filter," IEEE Trans. Power Del., vol. 24, no. 1, pp. 452– 461, Jan. 2009.

[9] Y. Hao, X. Tiantian, S. Paszczynski, and B. M. Wilamowski, "Advan- tages of radial basis function networks for dynamic system design," IEEE Trans. Ind. Electron., vol. 58, no. 12, pp. 5438–5450, Dec. 2011.

[10] I. Jung and G. N. Wang, "Pattern classification of back-propagation algorithm using exclusive connecting network," J. World Acad. Sci., Eng. Technol., vol. 36, pp. 189–193, Dec. 2007.

[11] B. Singh and J. Solanki, "A comparison of control algorithms for DSTATCOM," IEEE Trans. Ind. Electron., vol. 56, no. 7, pp. 2738–2745, Jul. 2009.

[12] A. Bhattacharya and C. Chakra borty, "A shunt active power filter with enhanced performance using ANN-based predictive and adaptive controllers," IEEE Trans. Ind. Electron., vol