Simulation and Analysis of a Multilevel Inverter for Power Quality Improvement

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Abstract-Interconnections of grid in power system have been done for economic purpose, reduction in electricity cost and to improve the reliability. However switching periods become large and there are some discrete operations present in the power grids. It becomes difficult to handle such changing loads smoothly. Immediate response to transient oscillations and to avoidsevere black-outs are the challenging part of the interconnected grid system.In the family of FACTS, STATCOM shows remarkable results in power quality improvement. In this paper different levels ofMLI has been discussed and simulated through which analysis of THD has been done.

Static Synchronous Compensator (STATCOM) regulates the voltage and corrects the power factor at thePoint of Common Coupling (PCC) by injecting reactive power [1]. Also, this device plays a vital role as a stability aid for small and large transient disturbances in an interconnected power system. Thispaper deals only with power-factor correction mode andshow theTotal Harmonic Distortion (THD).This paper presents analytical approaching a cascade H bridge 11 level multilevel STATCOM connected to power system for voltage regulation applications. The main objective of this paper is to maintain the voltage stability by compensating the reactive power in the power system. The multilevel STATCOM which can be used at the PCC, for improving power quality is modelled and simulated using proposed control strategy[2]. Simulations using MATLAB / SIMULINK are carried out to verify the performance of the proposed controller.

Keywords- Multilevel inverter (MLI), Total Harmonic Distortion (THD), Power-Factor Correction, Point of common coupling (PCC).

I. INTRODUCTION

Any change in the rated value of voltage and current at rated magnitude and frequency will be considered aspower quality issues [3]. Its impact isnoticeable in minimum andhigh voltage power transmissions because it affects the life cycle of the equipment's. Distortion in the sinusoidal wave which is also known as harmonics is the cause which reduces the life of equipment's sensitive to the variation in power supply. In case of high voltage transmission such distortion tends to sag, swell, voltage dip etc in the transmission and ultimately harms the quality supply of power distribution. Increasing use of power electronic devices in home appliances as well as in industries in combination with non-linear loads and unbalanced loads are the main cause of injection of harmonics in the supply system [4]. Hence filtration of power becomes essential. Many power filters became introduce and shows their benefits in this application. Any power conversion approach which diminishes theTDI by getting the output voltage in steps and taking the output nearer to a sine wave are known as multilevel inversion [5].

Static synchronous compensator gives precise control, faster response, reactivecompensation ability in transmission system devices. Multilevel inverter does the adjustments inamplitude andphase of the reactive component of current which is in AC side. This enablesmultilevel inverter to control the amount and direction oflow ofthe reactive power exchanged with the ac power system.

II. BASICS

Cascaded H-Bridge (CHB) showed its popularity in the field of HVAC transmission and variable speed drive applications [6]. It involves H Bridge units as an inverter having series connection. This is true for every phase of the supply system. Separate sources are provided for every H-Bridge. The source act as a battery for a power system. There is series connection of inverter level having AC terminal voltage. Again four switches are provided S1 to S4 for this connection. Through different combinations of the four switches, S1-S4, each converter level can generate three different voltage outputs, $+Vdc$, $-Vdc$and zero. A systematic output voltage which is building up can be generated by the series connection ac output voltage of the H Bridge inverter. This is nothing but summation of the individual converter output. Level of output voltage counts are different for different structures of MLI. With this topography, the number of output-phase voltage levels is defined by:

g = 2S + 1
Where, S= D.C. Sources counts,
g = Output Volts Level
For example in 7^{th} Level, 7= 2* 3 +1
g = 7
Distortions produced in the output waveform due to the presence of harmonic can be controlled by controlling angles of the levels.
Use of cascaded multilevel inverter can eliminate the requirement of:
a) Heavy transformer for traditional inverters.
b) Clamped diodes.
c) Flying capacitors.

Along with the above, some other features of MLI are:

1) Conventional inverter are not that much suitable for high power and high voltage implementation. But in the case of MLI these implementations are possible.
2) MLI gives pure sinusoidal waveform by incrementing level numbers [7].
3) Each bridge is fed with a separate DC source, it does not require voltage balance (sharing) circuits or voltage matching of the switching devices as inverter structure itself consists of a cascadeconnection of many single-phase, full-bridge inverter (FBI) units
4) To avoid bulky and loss resistor-capacitor-diode snobbery, soft-switching can be used.
Due to the above features of MLI the harmonic analysis is possible.

II. SIMULATION OF MULTILEVEL INVERTER:

Fig: 1Simulation for 11 level inverter

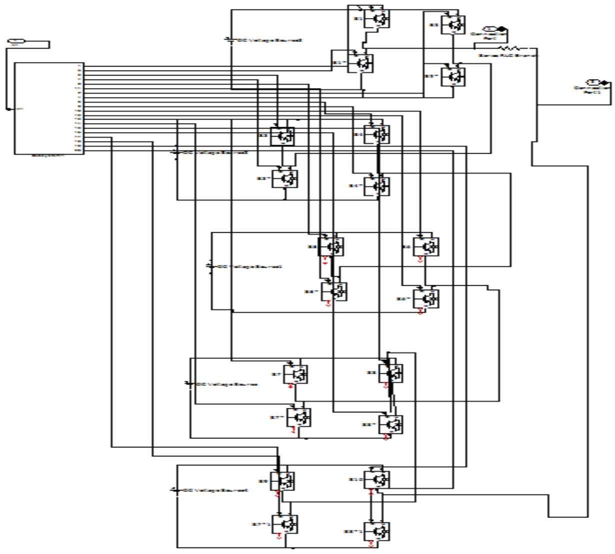


Fig: 2Simulation for 09 level inverter

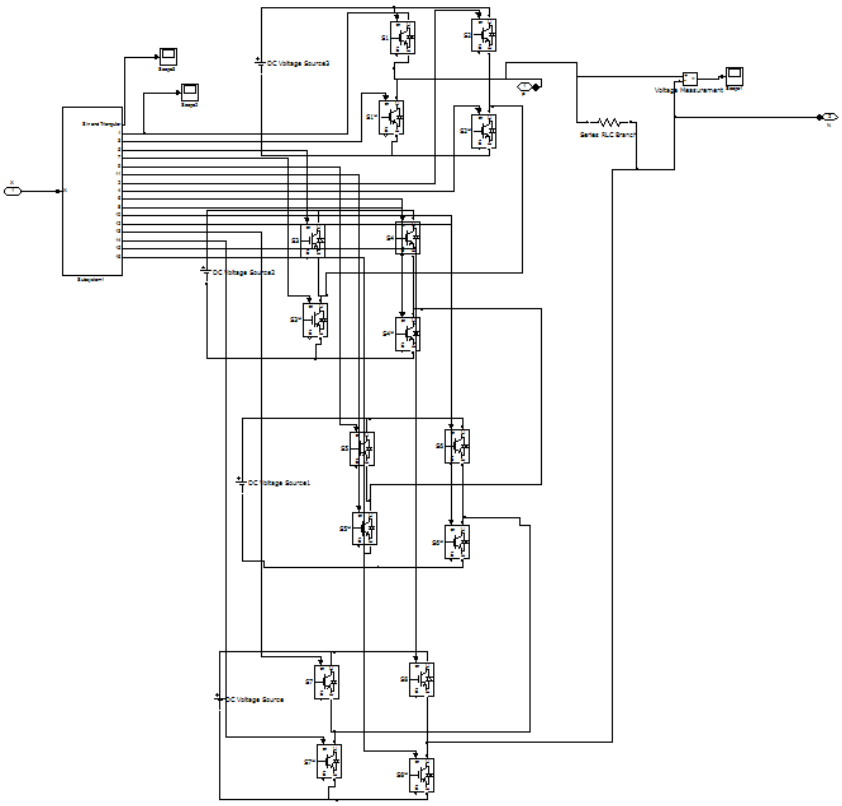


Fig:3 Simulation for 07 level inverter

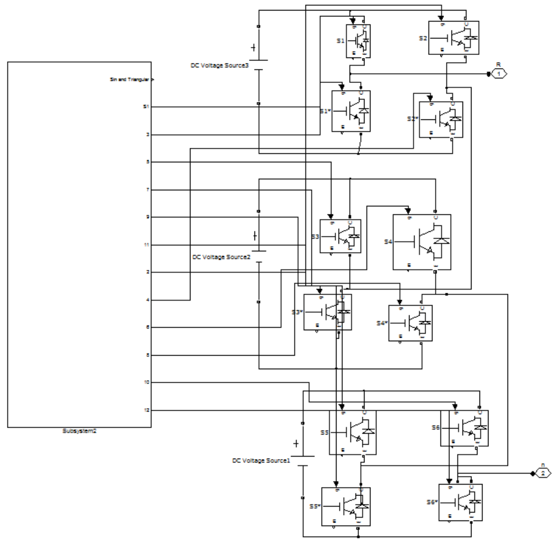


Fig:4Simulation for 05 level inverter

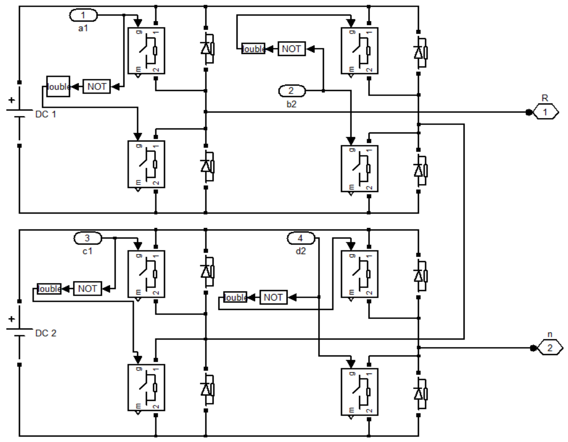


Table1: Levels and percentage THD

Sr. No.	Inverter levels	% THD
1	Five	35.03
2	Seven	14.30
3	Nine	13.68
4	Eleven	8.86

Fig5: 11kV Transmission system without MLI

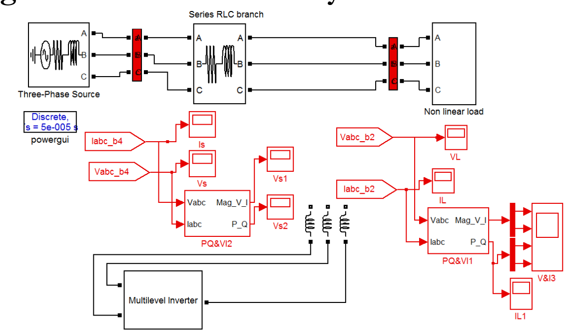
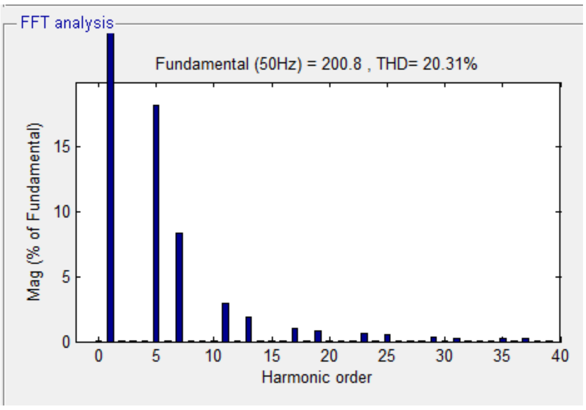


Fig:6 Without MLI source current THD result



Various components with their ratings are shown in the following table.

Table2: Ratings of components

Sr. No	Component	Rating
1	Supply System	11kV,50Hz
2	Source resistance	0.1 ohm
3	Source inductance	0.9 mH
4	3φRLC branch	R-10 Ω, L-10mH
5	Universal bridge as nonlinear load	Snubber R-1*10^6, Snubber C-1*10^-12
6	Inductance	10*10^-3
7	Subsystem 1	Rs-0.4Ω, L-1642*10^-6H C- 10*10^-6F, Rp- 20Ω
8	Subsystem 2 IGBT(16)	Internal resistance-1*10^-3Ω Snubber resistance-1*10^5Ω Snubber

Fig:7 11kV System with MLI

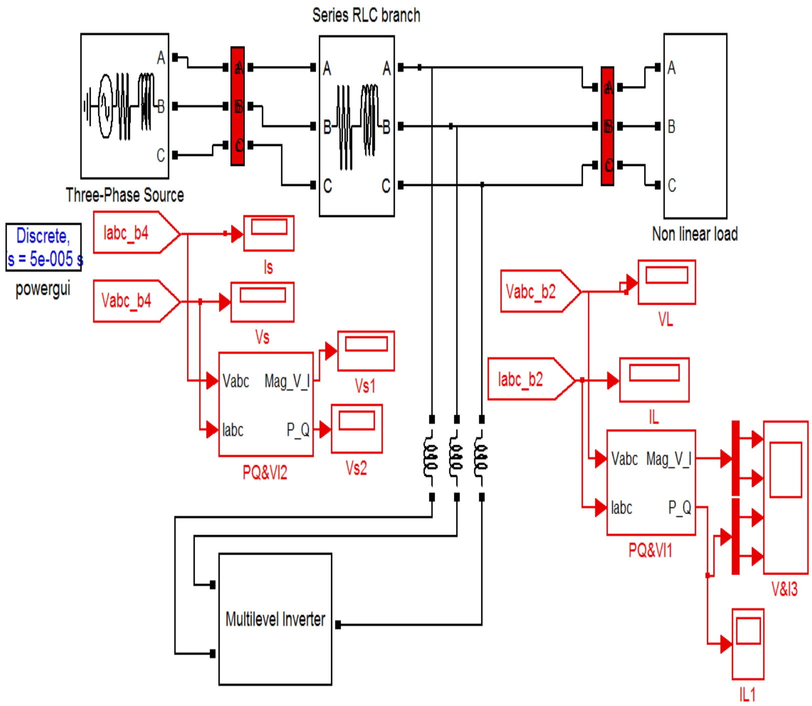
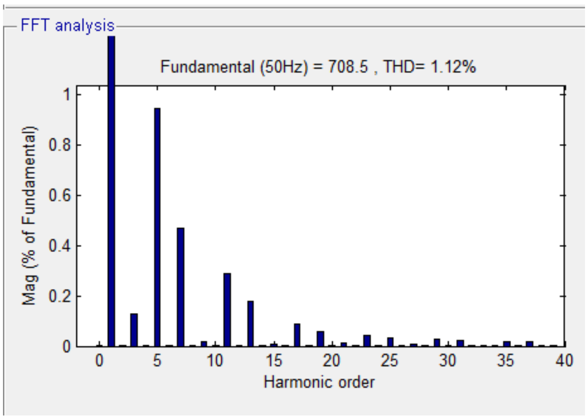


Fig8: Source current THD result



CONCLUSION

In this paper comparison between different MIL has been done. Also an 11kV transmission system has been simulatedfor THD in current with MLI and without MLI.It has been found that the percentage reduction in THD is fairly better. From the simulation result it has been proved that the three phase 11 levels MLI with suitable modulationtechnique, whenused for 11 kV transmission line has alleviated voltage sag, unbalancing and provided harmonic reduction under various load fluctuating conditions.

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