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# Harmonic Reduction in Multilevel Inverter

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***Abstract*—The aim of this paper is to present comparison of Harmonic reduction in multilevel inverter. The simulation of cascaded multilevel inverter for various stages using PWM (Pulse Width Modulation) is mentioned in SIMULINK/MATLAB Software. Comparison is done in terms of Total Harmonic Distortion (THD) in load voltage of various stages for multilevel inverter. As stages of Multilevel Inverter increases, the Total Harmonic Distortion (THD) reduces.**

***Keywords*— Multilevel Inverter, Harmonic Component, PWM (Pulse Width Modulation), Total Harmonic Distortion (THD),**

## I. INTRODUCTION

The Inverter is an electrical device which converts direct current (DC) to alternate current (AC). Now a day's many industrial applications have begun to require high power. Some appliances in the industries however require medium or low power for their operation. Using a high power source for all industrial loads may prove beneficial to some motors requiring high power, while it may damage the other loads. Some medium voltage motor drives and utility applications require medium voltage. The Multi level inverter is like an inverter and it is used for industrial applications as alternative in high power and medium voltage situations. Applications of Cascaded H-Bridge Multilevel Inverter are Motor drives, Active filters , Electric vehicle drives, DC power source utilization , Power factor compensators , Back to back frequency link systems, Interfacing with renewable energy resources etc. The advantages of multilevel Inverter are as follows Common mode Voltage, Input Current with low distortion, Higher & lower Switching Frequency, Reduced Harmonics Distortion etc[1].

Using multiple lower level DC voltages as an input, a multilevel inverter is capable of providing desired alternating voltage level at the output. Cascaded H-Bridge Multilevel inverter uses several H-bridge inverters connected in series to provide a sinusoidal output voltage [3].

Minimum harmonic content is the expectation from a power inverter. Various THD (Total Harmonics Distortion) techniques are demonstrated already. Few of them are reviewed in the literature survey such as switching angle calculation based on THD equation of multilevel inverter, FPGA based control algorithm, novel topology and fundamental frequency switching scheme etc [5].

This paper presents survey of various harmonics reduction techniques in second section. MATLAB/SIMULINK Simulation of different level cascaded multilevel inverter in third section. Fourth section discusses the results of respective simulated models. And last section concludes the paper.

## II. LETRATURE SURVEY

An algorithm used to calculate the switching angles of a cascaded multilevel inverter for minimizing the total harmonic distortion. This algorithm uses implementation of cascaded multilevel inverter with only one battery feeding one bridge and one transformer for each switching angle and connected in cascade with the other transformers. Compared with harmonic elimination, The THD resulted from switching angle calculation with this algorithm is lower. Up to fifteen levels, a list of switching angles for this is presented [1]. Power management control scheme managed the all possible power operation mode. Both reactive and harmonic current components drawn by nonlinear loads can be compensating by this proposed system [2].

In the area of high-power medium-voltage energy control, multilevel inverter technology plays very important role. Most important topologies like diode-clamped inverter (neutral-point clamped), capacitor-clamped (flying capacitor), and cascaded

Multicell with separate dc sources is presented in this paper. Control and modulation methods developed for this family of converters such as multilevel sinusoidal pulse width modulation, multilevel selective harmonic elimination, and space-vector modulation. Latest and more relevant applications of these converters such as laminators, conveyor belts, and unified power-flow controllers are also discussed here [3].

Two approaches for dc to ac power conversion such as cascaded H-Bridge Inverter and new Multi-level Scheme having Level Modules and H-Bridge. The simulation is done in SIMULINK/MATLAB. Comparison of two approaches with respect to Total Harmonic Distortion in output load voltage, active Power and reactive Power. The THD produced in second scheme and available active and reactive powers is better upto a certain stages of the first scheme are larger for the second scheme [4].

Using PI controller to perform unity power factor, single-phase five levels Pulse Width Modulation (PWM) inverter for grid connection proposes in this paper. To control the injected current into the grid to be almost sinusoidal, a digital proportional integral current control algorithm is implemented in FPGA XC3S400. The inverter offers much less total harmonic distortion [5].

A novel topology for single-phase 7-Level inverter is introduced. Switching strategy of the proposed inverter is discussed. A method and a formula are improved for calculating switching angles of the proposed inverter is presented in simulations. Simulation results are compared with conventional H-Bridge Inverter [6].

In electric utility and for industrial drives, Cascade Multilevel Inverters are very popular. The THD contents of 7, 11 and 15 level cascade multilevel inverters have been analysed. The THD analysis is carried out analytically as well as using MATLAB simulation (both results are in close agreement) by calculating switching angles [7].

Instead of taking a single set of solution a significant decrease in THD is obtained by considering multiple solution sets. For better understanding and to prove the effectiveness of the method, the computational results are shown graphically [8].

A novel double closed-loop PI controller design method for a three-phase inverter based on a binary-coded external optimization (BCEO) algorithm is presented in this paper. The total harmonic distortion and the integral of time weighted absolute error of output voltage waveform are weighted as the optimization objective function. A binary-coded external optimization (BCEO) algorithm is designed to solve this formulated problem [9].

Next section will introduce MATLAB SIMULINK models for three level & eight level inverter system.

## III. PROPOSED WORK

Three level Inverter SIMULATION model shown in Fig.1.Output voltage & THD (Total Harmonic Distortion) for three level inverter is shown in Fig.2. Eight level Inverter SIMULATION model shown in Fig.3.Output voltage & THD (Total Harmonic Distortion) for eight level inverter is shown in Fig.4.

Load voltage & Load current waveform is shown in simulation waveform. Different control algorithm provides the different shape of output load voltage & current. Harmonic components produced by three level & five level of inverter provided by simulation in MATLAB Software. Three level inverter provides THD (Total Harmonic Distortion) is 0.315 whereas eight level inverter provides THD (Total Harmonic Distortion) is 0.15. As level increases, the THD (Total Harmonic Distortion) component decreases depend on PWM (Pulse Width Modulation) technique utilized by system.

Next section will conclude the paper with some result characteristics.

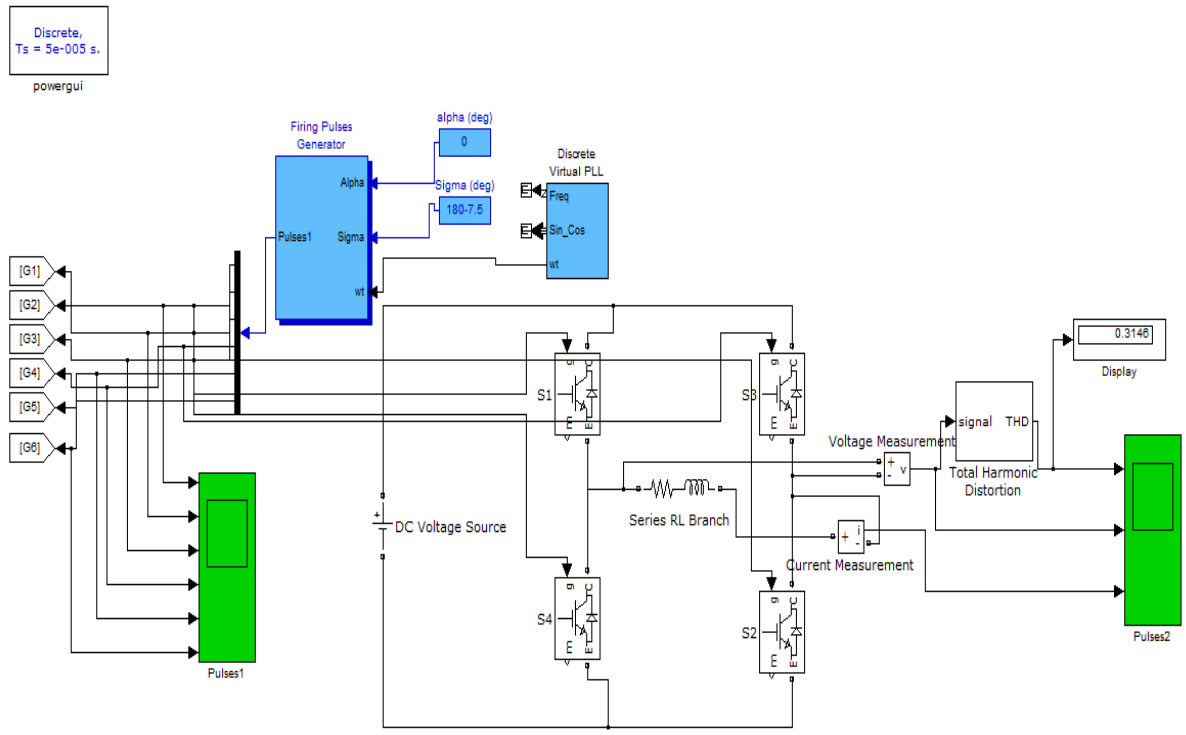


Fig.1.Three level Inverter SIMULATION model

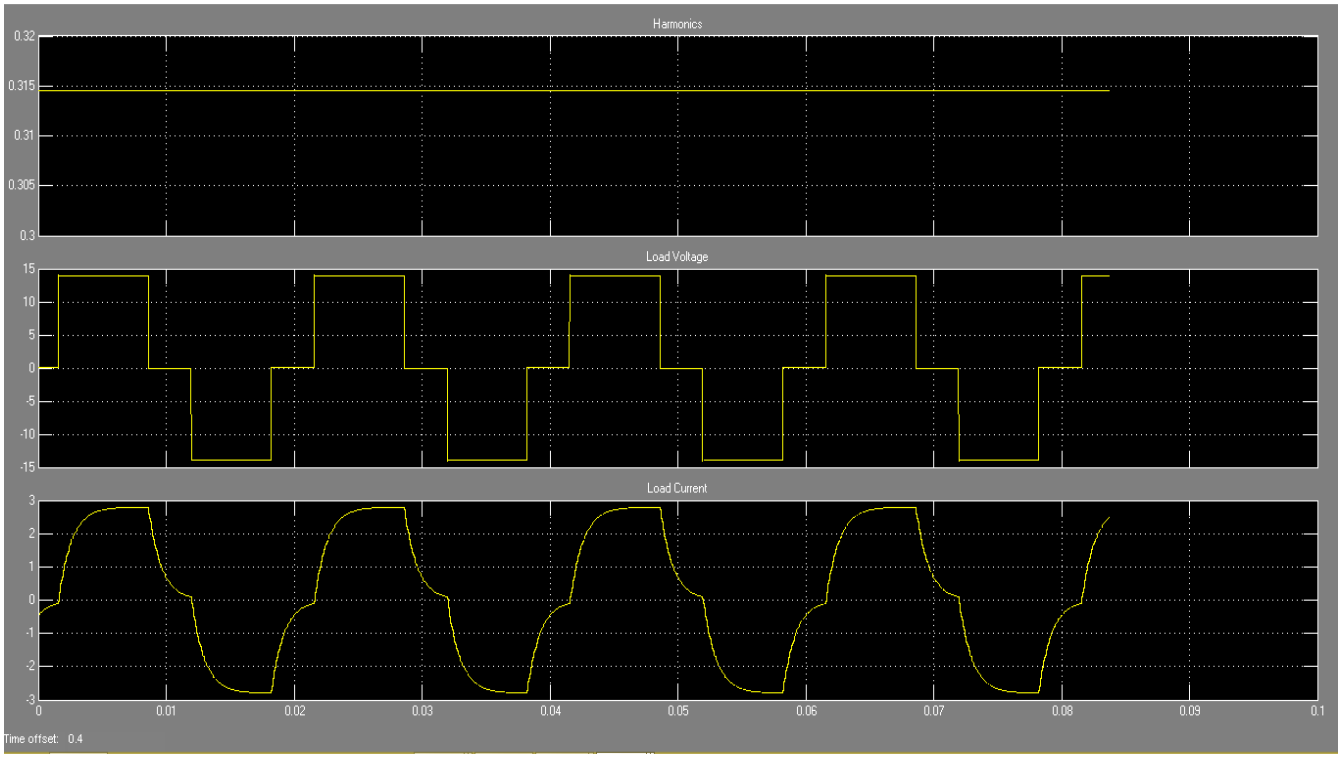


Fig.2.Three level Inverter SIMULATION Output voltage & THD

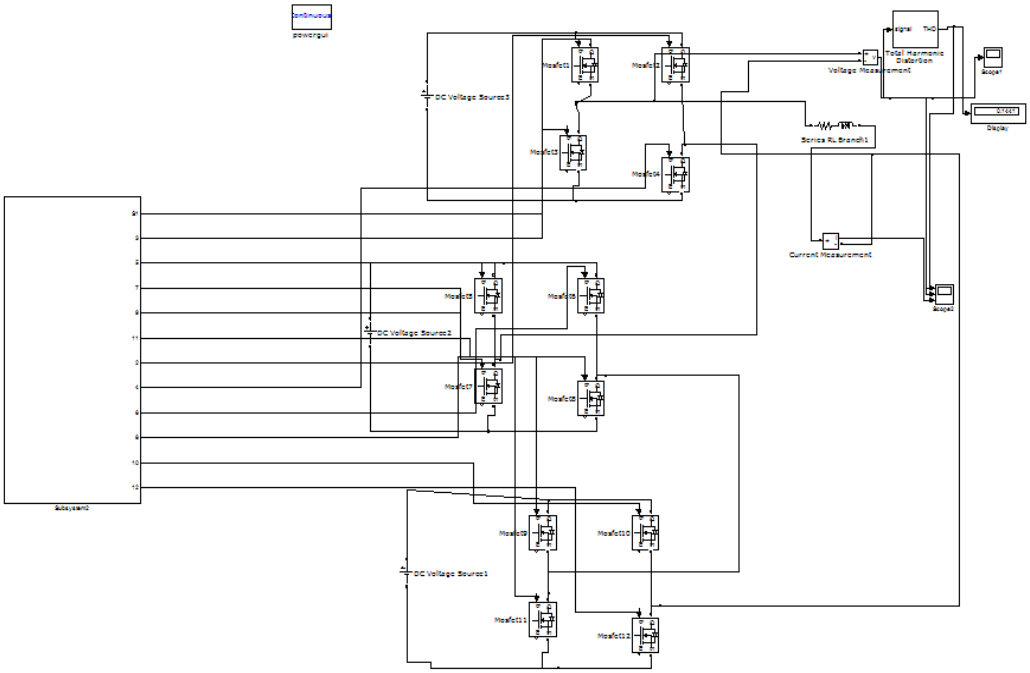

Fig.3.Eight level Inverter SIMULATION model

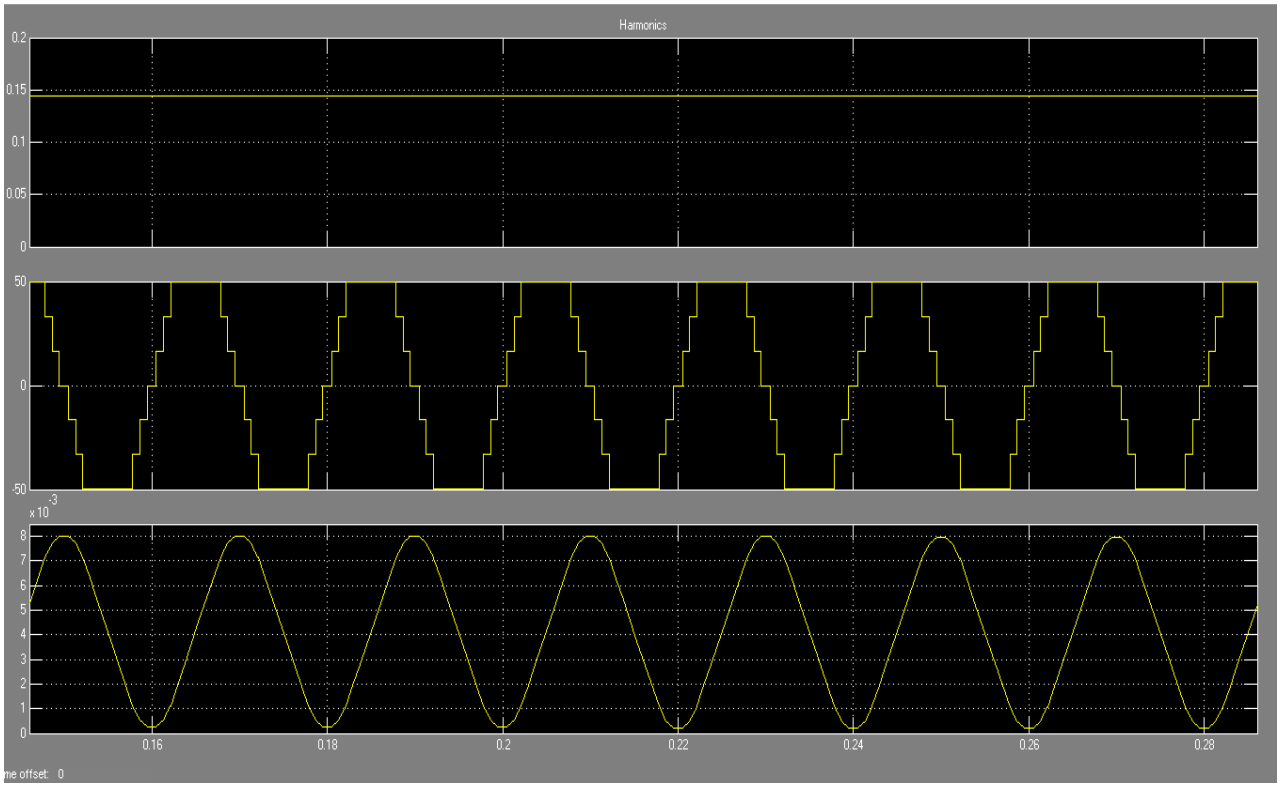

Fig.4.Eight level Inverter SIMULATION Output voltage & THD

## IV. CONCLUSIONS

Multilevel Inverter plays vital role in industrial & power applications. It is necessary to reduce the Harmonics Components in load voltage & Load current. Various techniques utilized for multilevel inverter are summarized in Literature Review. THD (Total Harmonics Distortion) measurement is done in MATLAB/SIMULINK Model. Three level of inverter provides THD is 0.351 approximately. Whereas five level of inverter provides THD is 0.15.

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