THD Analysis for Different Levels of Cascaded Multilevel Inverter Including Low Modulation and Over Modulation Indices

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Abstract— Cascade Multilevel Inverters are very popular and have many applications in electric utility and for industrial drives. When these inverters are used for industrial drive directly, the THD contents in output voltage of inverters is very significant index as the performance of drive depends very much on the quality of voltage applied to drive. In this article, the THD contents of 11 and 13 level cascade multilevel inverters have been analyzed.

Key words: THD, Multicarrier Pulse Width Modulation, Model of 11 Level and 13 Level Inverter

I. INTRODUCTION

Since past decade, multilevel inverters have drawn increasing attention because of their promising applications in power systems and industrial drives. They can be efficiently used in the distributed energy systems in which, output ac voltage is obtained by connecting dc sources such as batteries, fuel cells, solar cells, rectified wind turbines etc at input side of the inverters. The ac output voltage obtained from the inverters can be fed to a load directly or interconnect to the ac grid without voltage balancing problems. In addition, the multilevel inverters are used as voltage source inverters (VSIs) in the static synchronous compensator (STATCOM), a reactive power compensating device used for voltage regulation in power systems . There are mainly three types of multilevel inverters; these are a) diode- clamped, b) flying capacitor and c) cascade multilevel inverter (CMLI). Among these three, CMLI has a modular structure and requires least number of components as compared to other two topologies, and as a result, it is widely used for many applications in electrical engineering.

II. MULTICARRIER PULSE WIDTH MODULATION

The most popular and easiest technique to implement uses several triangle carrier signals and one reference, or modulation, signal per phase. For an m-level inverter, m-1 carriers with the same frequency $f_{c\ cvn,,}$and the same amplitude A_c are disposed such that the bands they occupy are contiguous. The reference waveform has peak-to-peak amplitude A_m, a frequency f_m, and its zero centered in the middle of the carrier set. The reference is continuously compared with each of the carrier signals. If the reference is greater than a carrier signal, then the active device corresponding to that carrier is switched on; and if the reference is less than a carrier signal, then the active device corresponding to that carrier is switched off. In multilevel inverters, the amplitude modulation index, m_a, and the frequency ratio, m_f, are defined as

$$m_a = \frac{A_m}{(m-1)\cdot A_c},$$

$$m_f = \frac{f_c}{f_m}.$$

III. MODEL OF 11 LEVEL AND 13 LEVEL INVERTER

For eleven level cascaded multilevel inverter reference signal is sinusoidal and carrier signal is triangular wave .
m -1 =10 number of carrier wave
m=11; m is number of level
Frequency of output of inverter is equal to the frequency of reference signal
V_{dc} =25volt

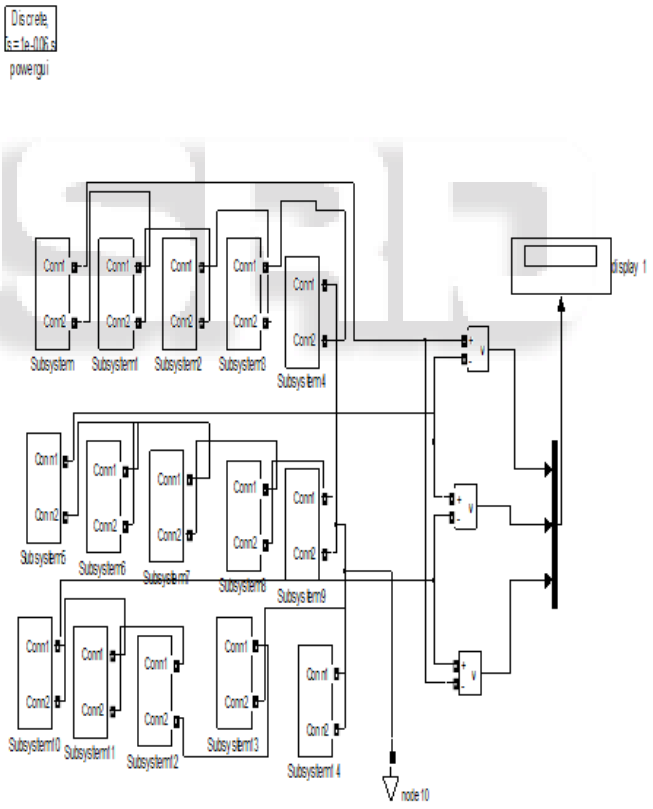


Fig. 1: Model of 11 Level Inverter

For thirteen level cascaded multilevel inverter reference signal is sinusoidal and carrier signal is triangular wave .
m-1=12 number of carrier wave
m=13;m is number of level
Frequency of output of inverter is equal to the frequency of reference signal
V_{dc} =25volt

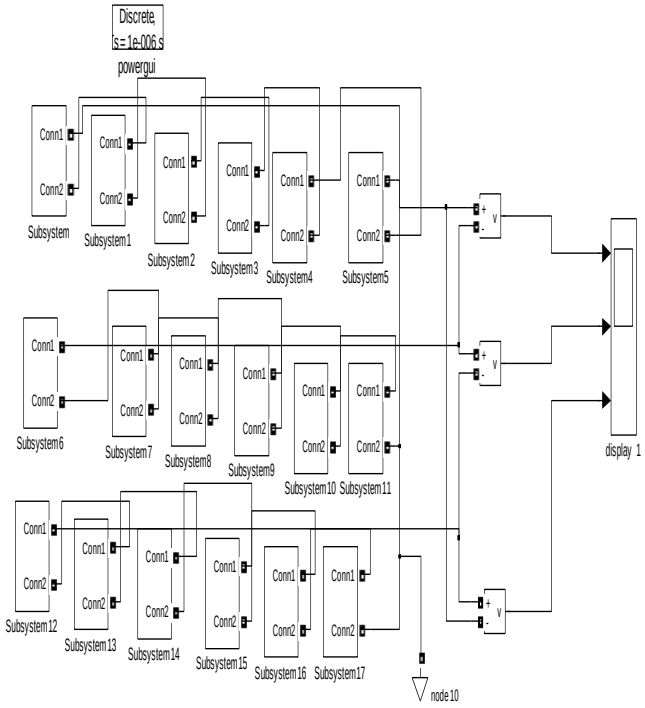


Fig. 2: Model Thirteen Level Inverter

IV. RESULTS

Simulation of 11level and 13 level inverter model is done using MATLAB.Simulation result of models and FFTanalysis presented.Fig.3.1 and Fig 3.2 presents waveform of LINE-LINE voltage and FFT spectrum of 11 level inverter. Fig.4.1 presents waveform of LINE-LINE voltage and FFT spectrum of 13 level inverter.

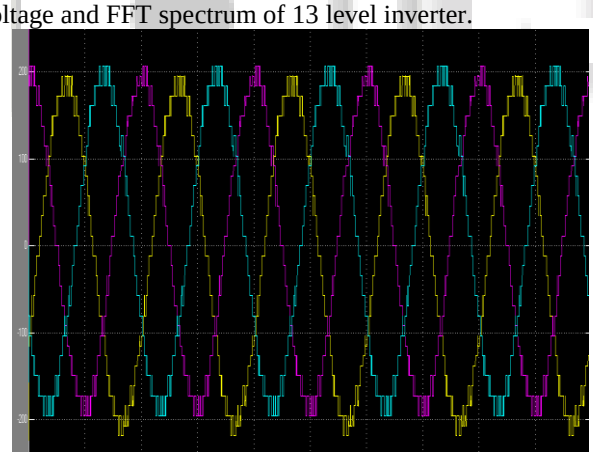


Fig 3.1: waveform of line-line voltage of 11 level inverter

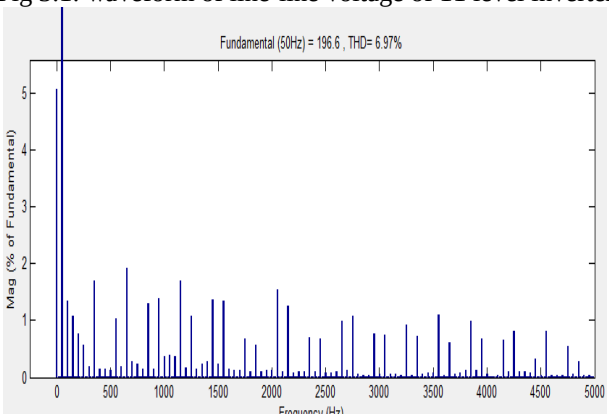


Fig 3.2: FFT Spectrum of 11 level inverter

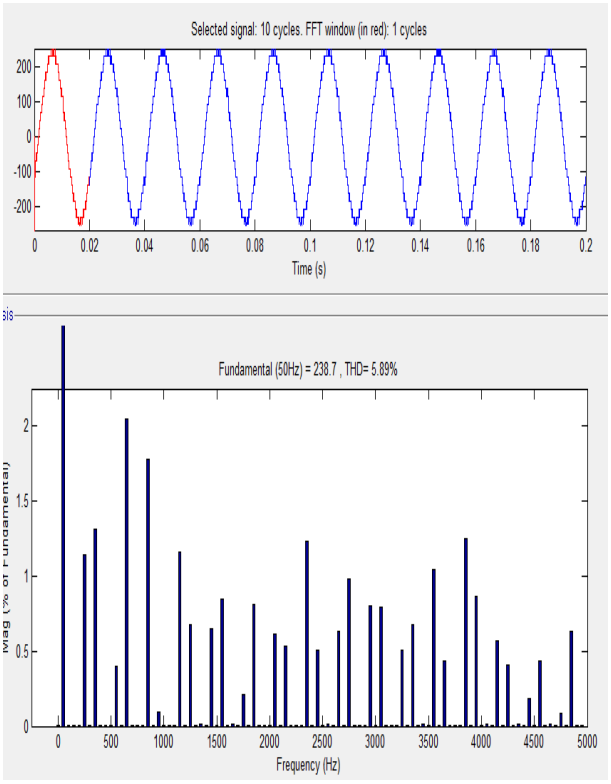


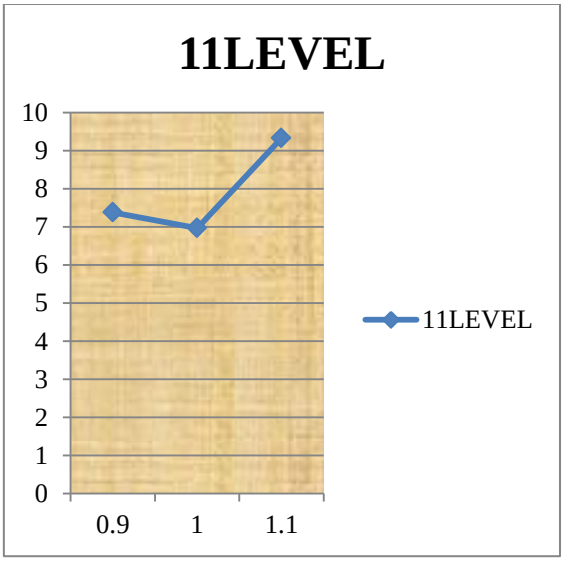
Fig. 4: Waveform of line-line voltage and FFT analysis of 13 level inverter

V. CONCLUSION

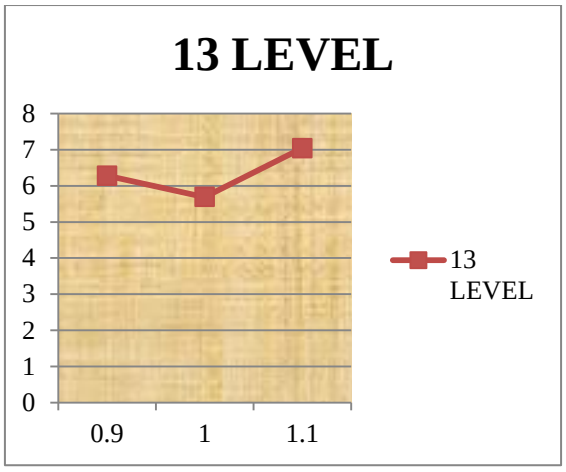
Table 1 shows the values of THD for 11 level and 13 level inverter at different modulation index.

Modulation Index	THD% 11Level	THD% 13Level
0.9	7.38	6.28
1	6.97	5.69
1.1	9.33	7.04

Table 1



Graph 1: Relation between THD% and modulation index for 11 level inverter



Graph 2: Relation between THD% and modulation index for 13 level inverter

It can be observed that THD is better for 13 level inverter

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