Performance Analysis and Comparison of Nine Level and Eleven Level NPC Inverter

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Abstract— This paper deals with the comparison of nine level and eleven level neutral point clamped inverter .A conventional voltage source inverter (VSI) is modelled and simulated using matlab.FFT Analysis is done to study the reduction in Total Harmonic distortion (THD).Multilevel converter is used to increase high level output voltage magnitude ,reducing the output voltage and current harmonic content make output voltage closer to sinusoidal wave the switching frequency.

Key words: Multilevel inverter, Voltage source inverter, matlab Simulink, Modulation index.

I. INTRODUCTION

Many industrial applications have begun to use high power apparatus in recent year. Medium power motor drives and utilities require medium voltage and higher power level. In a medium voltage grid, connecting only one power semiconductor switch directly will create problem. To overcome this problem, a multilevel inverter topology has been introduced as an alternative in medium voltage and high power situations. A multilevel inverter use renewable energy as source and can achieve high power rating. So, renewable energy sources such as solar, fuel cells and wind can be easily interfaced to a multilevel inverter structure for a high-power application. The multilevel inverter concept has been used since past three decades. The multilevel inverter begins with a three-level inverter. Thereafter, many multilevel inverter topologies have been developed. However, the main concept of a multilevel inverter is to achieve high power with use of many power semiconductor switches and numerous low voltage dc sources to obtain the power conversion that lookalike a staircase voltage waveform. The dc voltage sources for multilevel inverter are given by battery, renewable energy and capacitor voltage sources. The proper switching of the power switches combines these multiple dc sources to achieve high power output voltage. The voltage rating of the power semiconductor devices depend sonly upon the total peak value of the dc voltage source that is connected to the device. Three major classification of multilevel inverter structures [1-3] are cascaded H-bridge inverter with separate dc source, diode clamped (neutral-clamped), and flying capacitor (capacitor clamped).

A. Multilevel inverter

Multilevel inverter is best suited in power sector. It is used as to control the active and reactive power of grid .In the grid control system multilevel inverter is used to

(1) The stability of dc voltage.
(2) Inverter power factor is unity.
(3) Input current contain low harmonics [4].

The general function of multilevel inverter is to synthesize the dc voltage source. Multilevel inverter have capability to increase the high step up voltage without the use of transformer [5]-[9]. By choosing appropriate angle of multilevel inverter we can eliminate the harmonics in a specified output waveform. The necessary conduction angle can be calculated by choosing appropriate phase voltage the output voltage Va0 can be given as [10]-[13]:-

$$Vao = Va_1 + Va_2 + Va_3 + Va_4 + \dots \quad (1)$$

Since the waveform is symmetrical to X-axis hence the Fourier coefficient An and Ao become zero. Hence only the analysis of Bn is perform:

The standard Fourier series equation are given below

$$f(x) = a_0 + \sum_{n=1}^{\infty} \left(a_n \cos\frac{n\pi x}{L} + b_n \sin\frac{n\pi x}{L}\right) \dots \quad (2)$$

in term of Bn the equation can be written as:

$$Bn = \left(\frac{4Vdc}{n\pi}\right) \sum_{j=1}^{\infty} COS(n\alpha_\kappa) \dots \quad (3)$$

j = no. Of dc source
n= no of odd harmonics
α_κ = switching angle of level k
By solving above equation (3)

$$\cos\alpha_1 + \cos\alpha_2 + \dots \dots \dots \cos\alpha_k = \frac{jM}{4}$$

$$\cos 3\alpha_1 + \cos 3\alpha_2 + \dots + \cos 3\alpha_K = 0$$

$$\cos 5\alpha_1 + \cos 5\alpha_2 + \dots + \cos 5\alpha_K = 0$$

The above equation can be solved by using Newton Raphsonmethod to find switching angle.

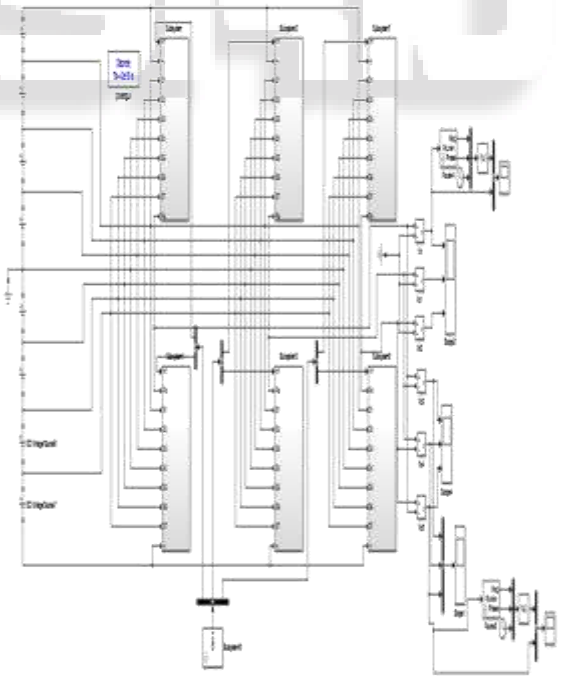

Fig. 1: Simulink model of nine level inverter

II. SIMULATION RESULTS OF NINE LEVEL INVERTER

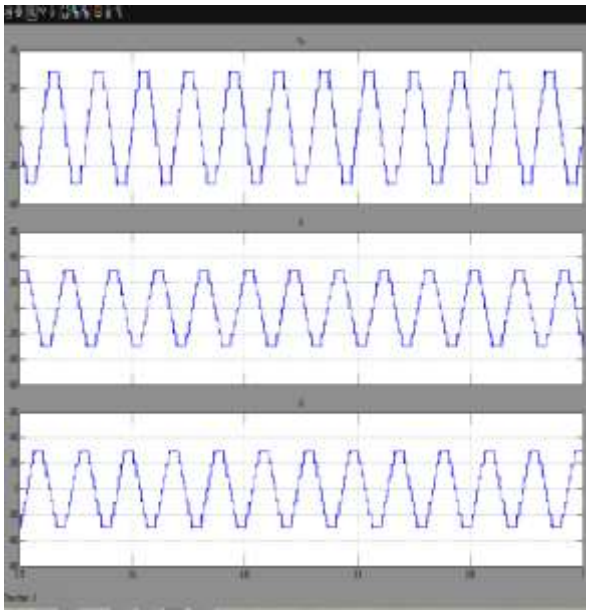

Fig. 2: phase voltage waveform of nine level inverter

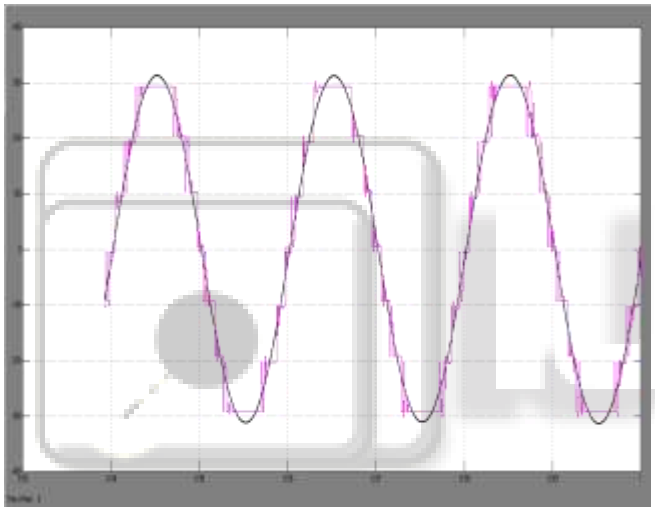

Fig. 3: Fourier phase magnitude waveform

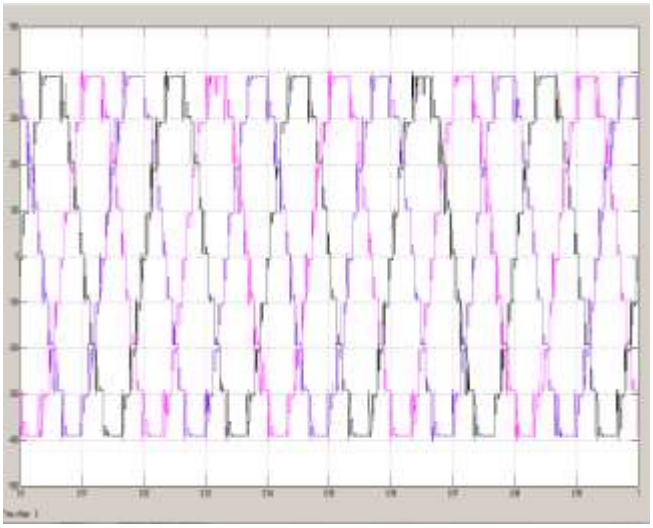

Fig. 4: phase voltage waveform

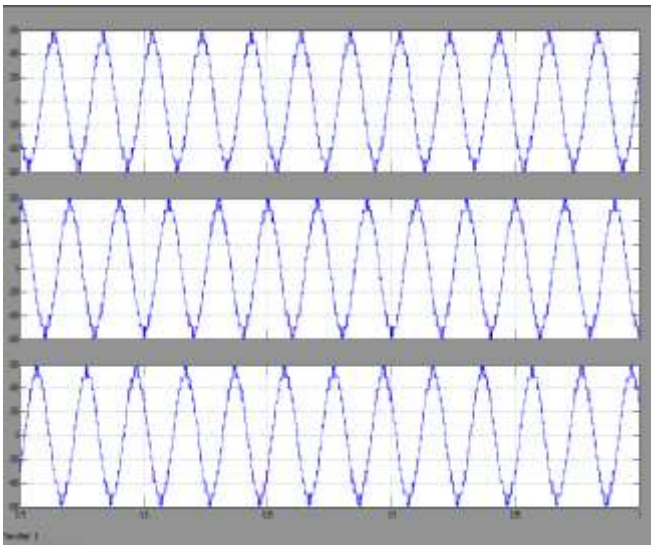

Fig. 5: line voltage of nine level inverter

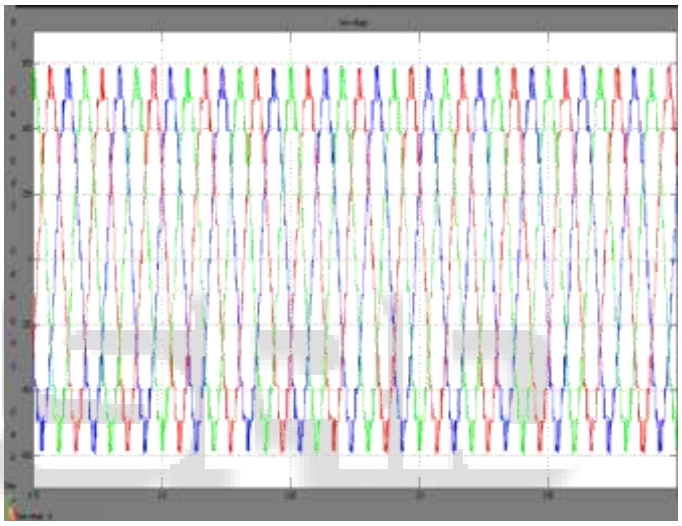

Fig. 6: line voltage waveform

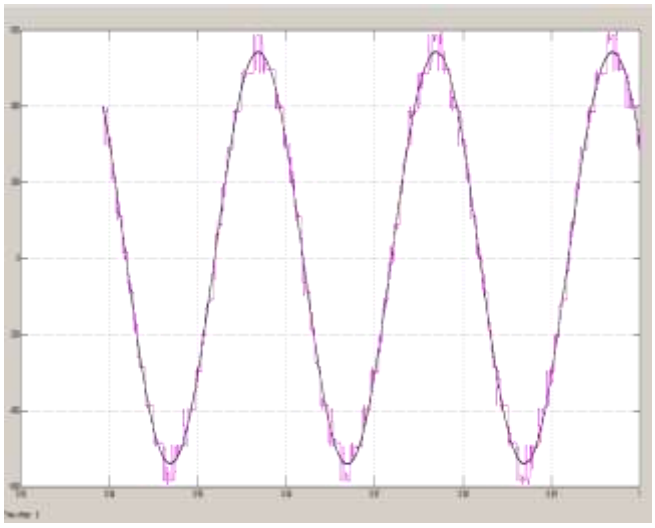

Fig. 7: Fourier line magnitude waveform

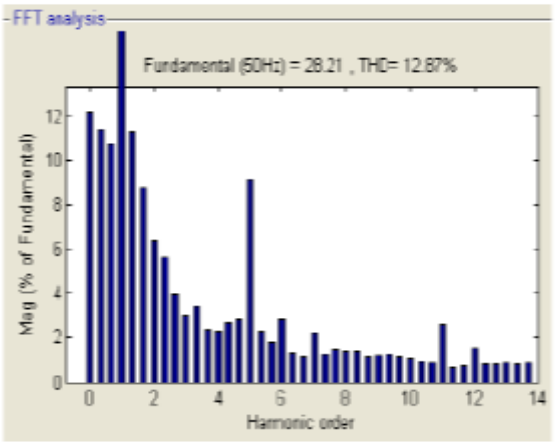

Fig. 8: FFT analysis of nine level inverter

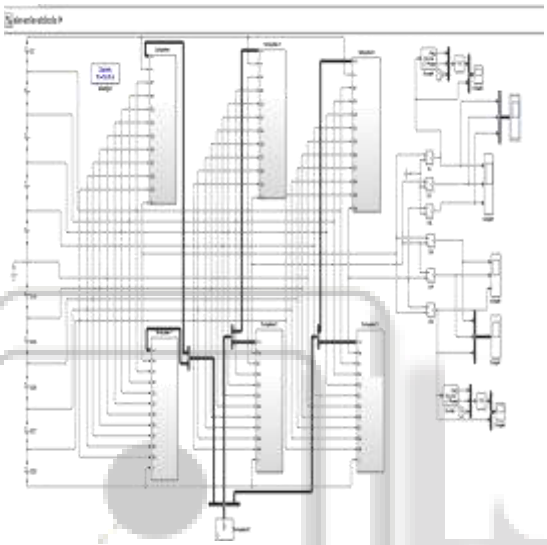

Fig. 9: Simulink model of eleven level inverter

III. SIMULATION RESULT OF ELEVEN LEVEL INVERTER

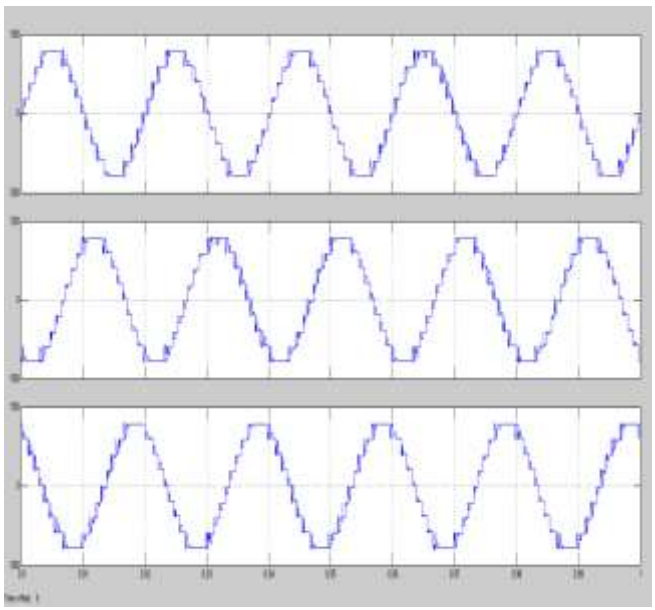

Fig. 10: phase voltage waveform

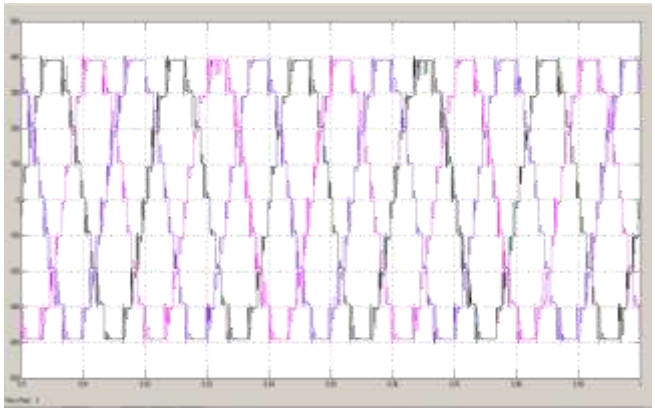

Fig. 11: phase voltage waveform

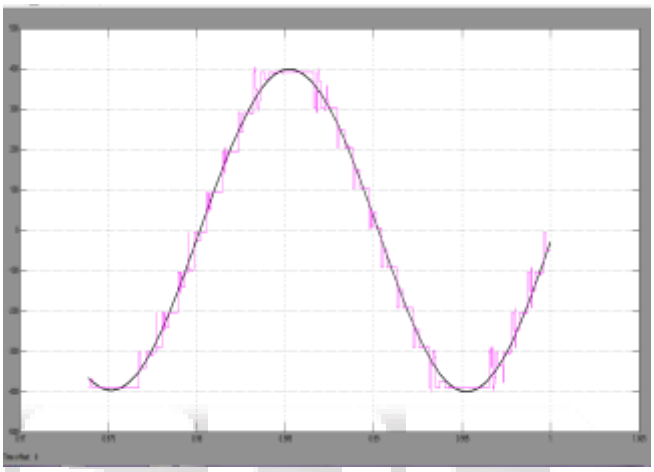

Fig. 12: Fourier phase voltage of eleven level inverter

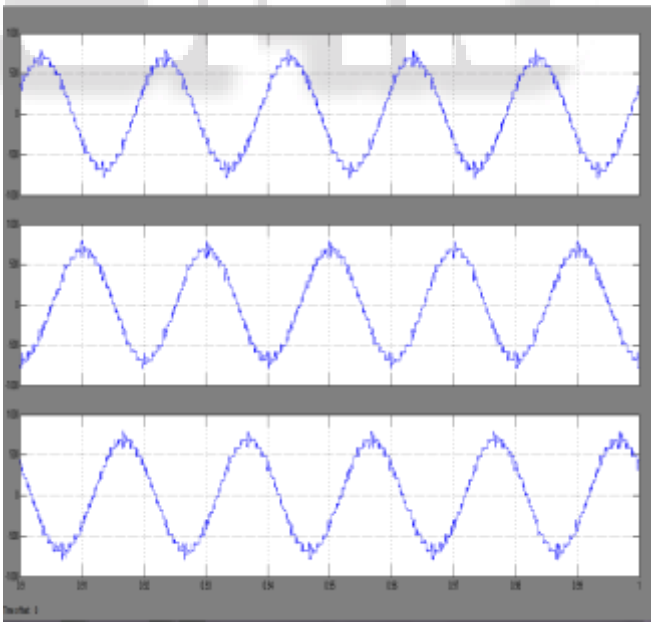

Fig. 13: line voltage of eleven level inverter

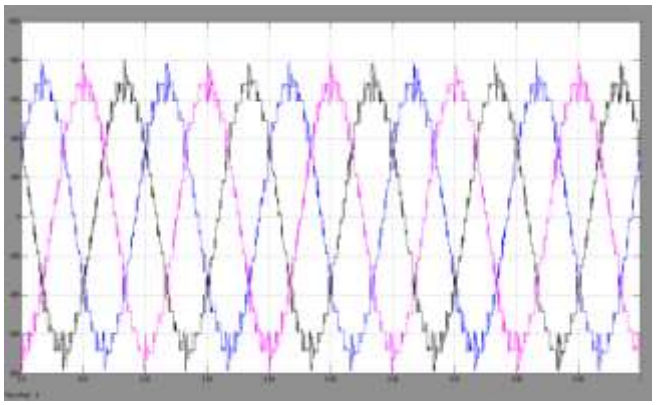

Fig: (14) line voltage of eleven level inverter

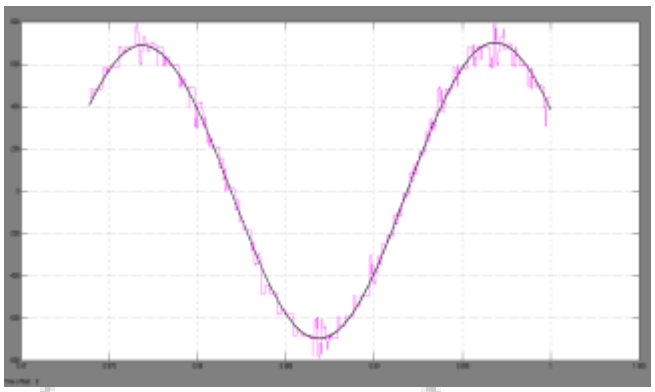

Fig (15) line voltage of eleven level inverter

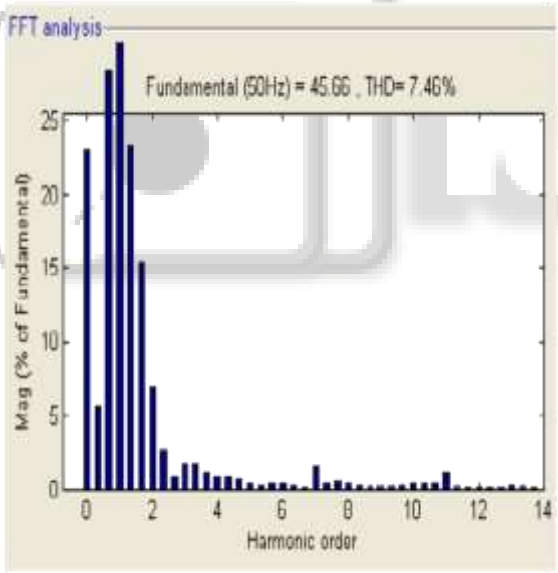

Fig. 16: FFT Analysis for eleven level inverter

IV. CONCLUSION

From the above we can conclude that as the level of inverter Increases line and phase voltage waveform increase and the harmonic induced is decreases. Using eleven levels neutral point clamped converter and nine levels NPC the harmonics reduces significantly. This is the advantage of multilevel inverter. From the FFT analysis of nine level NPC inverter and eleven level NPC inverter the THD of nine level is 12.87% which has more than eleven level NPC inverter is 7.46% i.e. as the level of inverter increases THD decreases.

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