ISSN No: - 2456- 2165

Comparatively Study between Five Level and Seventeen Level Multilevel Inverter by Cascade PWM Technique

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Abstract— **The multilevel inverter occupancy rate has increased since the last decade. Multilevel converter is suitable for high power application as a result of their ability to synthesize waveforms with an improved harmonic spectrum and faithful output. In conventional cascade H-bridge is that when the voltage increases, an increase in the number of semiconductor switches and also the source requirement increases. In order to overcome this introduced a new topology of cascaded H-bridge. This new topology gives less order of THD with controlled tension. This paper presents seventeen level inverter with PWM techniques that are used in Hybrid Electric Vehicle for very high efficiency to stabilize as a result of the inverter output voltage. With 5-level and 17-level, we can distinguish that the manner in which THD influence by increasing the levels in both cases, in MATLAB Simulink. Cascade PWM converter is used for the advantage of simple control strategy. PWM (Pulse Width Modulation) method is used to generate the gate drive signal to the controller. However, the proposed topology be expanded with an n-level inverter.**

Keywords- Multilevel Inverter, PWM, Cascade H-Bridge Topology, THD

I. INTRODUCTION

In recent years, multi-level inverter (MLIS) received much attention due to their ability to be used in heavy-duty DC to AC conversion [2-5] and was in 1981 [1] and is the subject of power electronic Research. MLIS also a viable option for use in distributed power systems [6] due to the reduction in total harmonic distortion (THD) that the total power quality of a given system [7] improves. MLIS have the following advantage i.e., lower THD, lower electromagnetic interference (EMI) and lower dv /dt stresses on the load [1] .The most common MLI topologies are: diode clamped inverter [7], flying capacitor inverter [8] and cascade converter. In this article, PWM method is used to generate the gate signals for the inverter proposed.

PWM multilevel converter is usually an extension of two-level methods [9-12]. The most common forms of multilevel voltage-source PWM are sine-triangle modulation and space vector modulation (SVM). Multilevel sine-triangle modulation is based on the definition of a number of triangular waveforms and switching rules for the crossing of these wave shapes with a commanded voltage waveform [2-4] .

The cascade multilevel inverter typically comprises a plurality of identical single-phase H-bridge cells cascaded in series to the output side. This configuration is commonly referred to as a cascade H-bridge, which can be considered to be symmetric if the DC voltages equal all the series of energy cells or asymmetrical or otherwise. In an asymmetric CHB, dc voltages are varied in order to produce more output levels. In this article, we are using new topology of cascade H-bridge multilevel inverter for producing seventeen output voltage levels for the analysis of the THD, and to compare it with a simple five-level inverter cascade THD.

II. PULSE WIDTH MODULATION

. In this inverter, using the sinusoidal pulse width modulation is going. In the sinusoidal pulse width modulation scheme, when the switch on and off is varied several times during each half-cycle, the width of the pulses in order to change the output voltage. Lower order harmonics can be eliminated or reduced by the type of modulation of the pulse widths and the number of pulses per half period. Higher harmonics can increase, but these are of interest because they can be easily removed by filters. The SPWM is focused on the generation of a sinusoidal inverter output voltage without a low-harmonics. This is possible if the sampling frequency is high compared to the fundamental output frequency of the inverter. The modulation index M is determined by the proposed multilevel inverter,

$$M= ½ (V_{ref} / V_{cr}) \qquad ..... (1)$$

Where in V_{ref} to the amplitude of the voltage reference and V_{cr} is the amplitude of the carrier signal. Multi-carrier phase-shifted PWM (CPS-PWM) [7] is used to generate the modulation PWM. The amplitude and frequency of triangular carriers are the same as the phase shifts between adjacent carriers. Depending on the number of cells, the carrier phase rotation for each cell, θ_{cr}, n are available,

$$\theta_{cr},n = 2\pi(n-1)/N_c \qquad .....(2)$$

$n= 1,2,………..N_c$

For signal generation in each cell, two voltage references and one carrier signal are used. V_{ref} is defined by

$$V_{ref}= M \sin \omega t \quad .....(3)$$

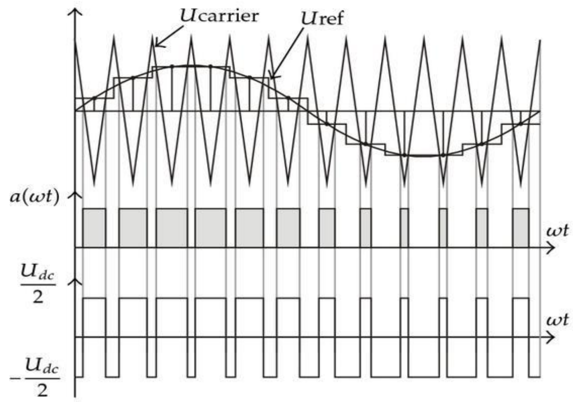

Fig.1 Waveform of PWM

III. CONCEPT OF MULTILEVEL INVERTER

A multilevel inverter a power electronic device that are capable of desired AC voltage at the output with multiple lower DC voltage as an input. Usually, a two-level controller used to generate the alternating voltage of DC voltage. Now the question arises what is the need of using multilevel inverter when we two-level inverter. To answer this question, we must first look at the concept of multilevel inverter.

First, take the case of a two-level inverter. A two-level inverter allows two different voltages for the load that is to say, suppose that we are providing VDC input for a two-level inverter then the + Vdc / 2 and offer - Vdc / 2 on the output. To build an alternating voltage, usually on the two newly generated tensions. For most of the PWM switching is used, as shown reference wave is shown in the figure (2) in blue dashed line. Although this method to AC is effective, but it has some drawbacks since this is a harmonic distortion in the output voltage, and also has a high dv / dt in comparison with that of a multilevel converter. Typically, this method works, but in some applications, it is problematic in particular, where low distortion of the output voltage is required.

The concept of Multilevel Inverter (MLI) is a kind of modification of two-level inverter. In multilevel inverters, we do not relate to the two-level voltage rather than to create a stepped waveform smoother, are more than two voltage levels are combined and the output waveform obtained in this case a lower dv / dt as well as lower harmonic distortion.

Smoothness of the waveform is proportional to the voltage of the voltage levels, we increase the waveform smoother but the complexity of the control circuit components and also increases along with the increased levels. The waveform of the three, five and seven level converters is shown in the figure 3 , where we clear that increasing the levels of, waveform increasingly smoother.

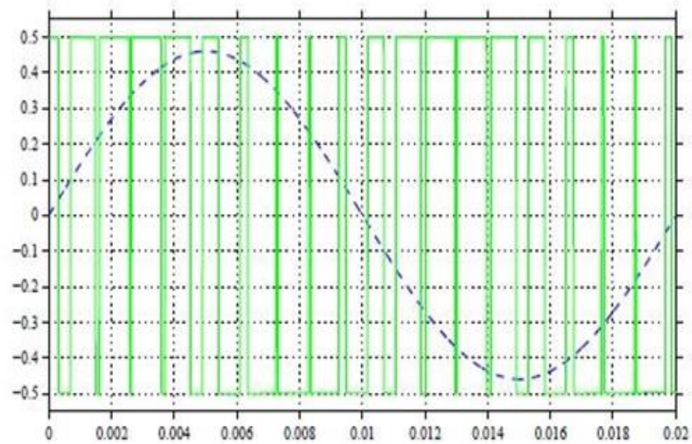

Fig.2 PWM voltage output of a two-level inverter

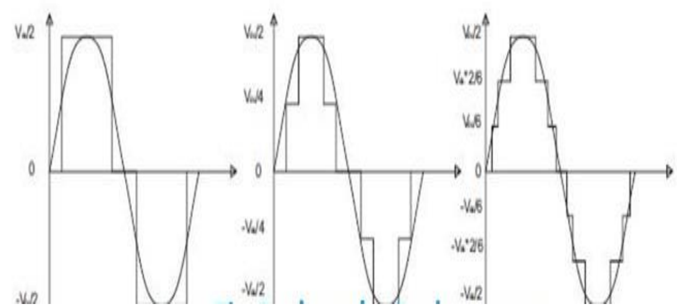

Fig.3 A three-level waveform, a five-level waveform and a seven-level multilevel waveform, switched at fundamental frequency.

IV. MULTILEVEL INVERTER TOPOLOGIES

There are several topologies of multilevel inverters available. The difference lies in the mechanism of switching and the source of input voltage to the multilevel inverters. Three most commonly used multilevel inverter topologies are:-

- Cascaded H-bridge multilevel inverters
- Diode Clamped multilevel inverters
- Flying Capacitor multilevel inverters

A) Cascaded H-Bridge Multilevel Inverters

This converter uses a variety of H-bridge inverters connected in series with a sinusoidal output voltage. Each cell contains an H-bridge and the output voltage provided by this multi-level inverter actually the sum of the yield of each cell, for example, if there are k cells in an H-bridge multilevel inverter voltages than number of output voltage levels will 2k 1. This type of inverter has advantages over the other two as the fewer number of

ISSN No: - 2456- 2165

components in comparison with the other two types of inverters, and thus the total weight and price is also for writes. Figure 4 shows a N level cascade H-bridge inverter.

B) Five Level Multilevel Inverter

Figure 5 shows the new five-level cascade H-bridge multilevel inverter [6]. It still has a bidirectional switch connected between the first leg of the H-bridge and the capacitor midpoint, so that five output voltage levels

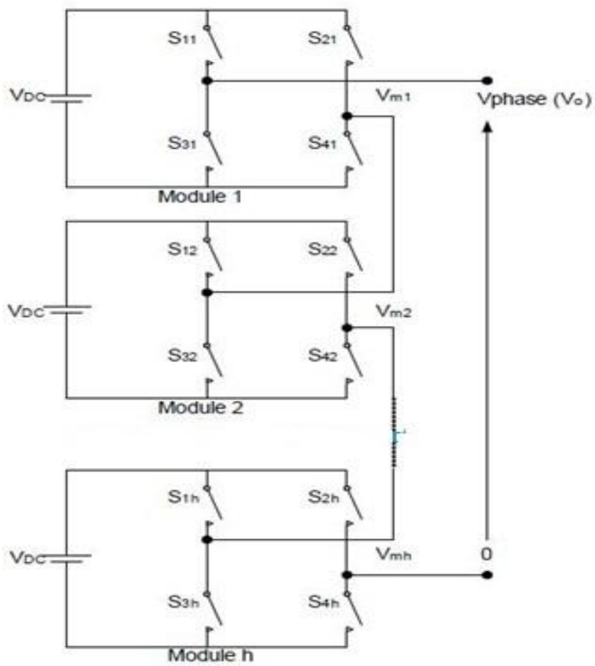

Fig. 4 Cascaded multilevel inverter

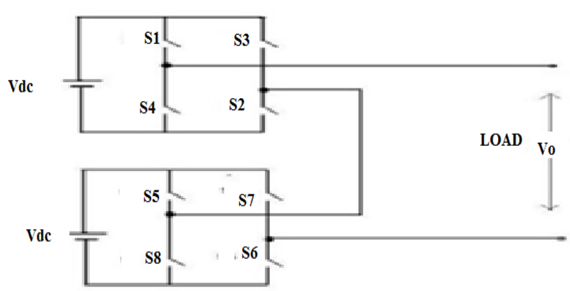

Fig.5 Circuit diagram of cascaded 5 level multilevel inverter

It has five output voltage levels ie V_{dc}, V_{dc} / 2, 0, -V_{dc} / 2 -V_{dc}. be activated for obtaining the output voltage Vdc, the switches S2S5need. The same applies must be enabled for output voltage V_{dc} / 2switches S1S5 be enabled for 0 or S3S5 or S2S4need; for - V_{dc} / 2 switches S1S4 should be involved; for - Vdc switches S3S4 should be involved. The switch combinations are shown in Table 1.

V/S	S1	S2	S3	S4	S5	S6	S7	S8
0	0	0	0	0	0	0	0	0
V1	1	1	0	0	0	0	0	0
V2	1	1	0	0	1	1	0	0
V1	1	1	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
-V1	0	0	1	1	0	0	0	0
-V2	0	0	1	1	0	0	1	1
-V1	0	0	1	1	0	0	0	0

Table 1

In the circuit in Figure 1, an H-bridge module is capable of producing output five voltage levels. Each drive module is capable of 2V, V, 0, -V is, 2V shown in Table 1.Theoretical Calculation for THD Using Pulse Generator.

The total harmonic distortion can be calculated using the formula for 5 level inverter

$$THD = \left(\frac{\sqrt{(V_2{}^2 + V_3{}^2 + V_4{}^2 + \cdots + V_n{}^2)}}{V_1} \right) * 100$$

$$THD = \sqrt{4^2 + 3^2 + 3.6^2 + 5^2 + 6^2 + 7.8^2} / 3.7$$

$$35.33\% \qquad ......(4)$$

C) Seventeen Level Multilevel Inverter

Conventional multilevel converter have been used for decades for converting direct current into alternating current power. This method is useful to the low levels, such as three levels, five levels, but these conventional multilevel inverters in the case of a high level are not favorable, because a high level which is generally used for higher harmonics in a power devices such as electric motor suppress FACTS controllers, etc. required large number of switches and in that this circuit become more complex and, problems arise in the analysis of the harmonic distortion. So, we have new multilevel inverter topology that is used new cascade H-bridge multilevel inverter.

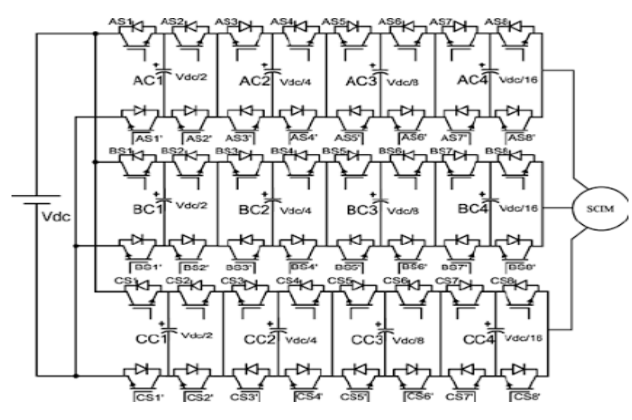

Fig. 6 Three phase seventeen level multilevel inverter

This topology does not diminish. switches by cascading the one circuit to the other. As we have studied cascade five-level inverter so, the desired we eight bridges cascade of five-level multilevel converter for the formation of seventeen level cascade H-bridge multilevel inverter

$$THD = \sqrt{3^2 + 4^2 + 5^2 + 6^2 + 7}\ /3.7 = 13.67\% \quad .....(5)$$

V. SIMULATION AND RESULTS

The circuit was simulated with R load. Figure 4 and 5 shows the output waveform of five level and seventeen level cascaded H-bridge multilevel inverter with modulation. A THD analysis was done and the result obtained is as shown in figure (7) and Figure (8).

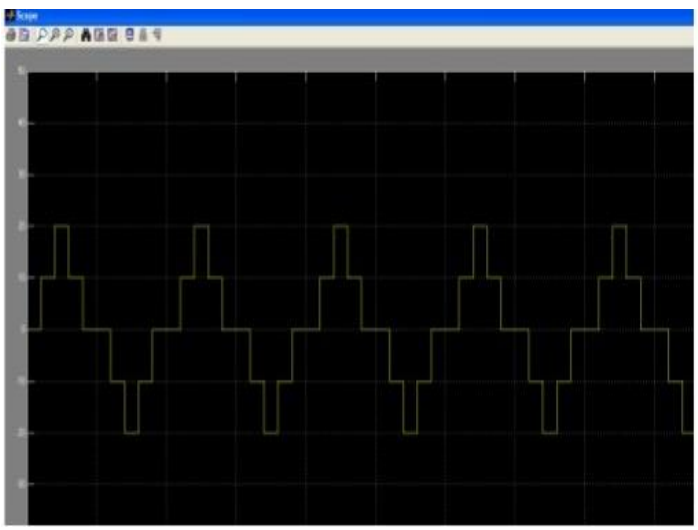

Fig 7. Output voltage waveform of 5 level cascaded H-bridge inverter

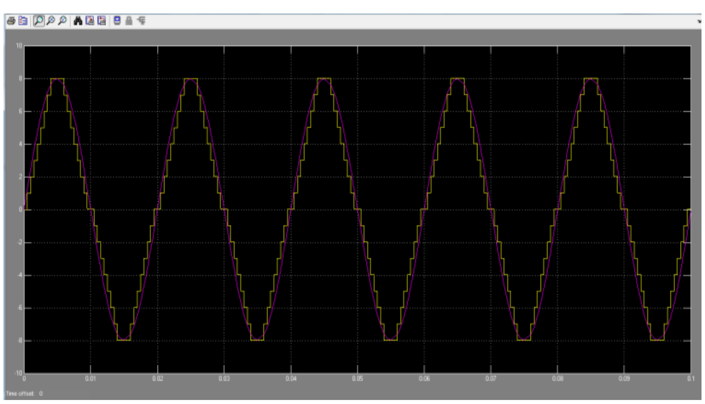

Fig.8 Output voltage waveform of 17 level cascaded H-bridge multilevel inverter

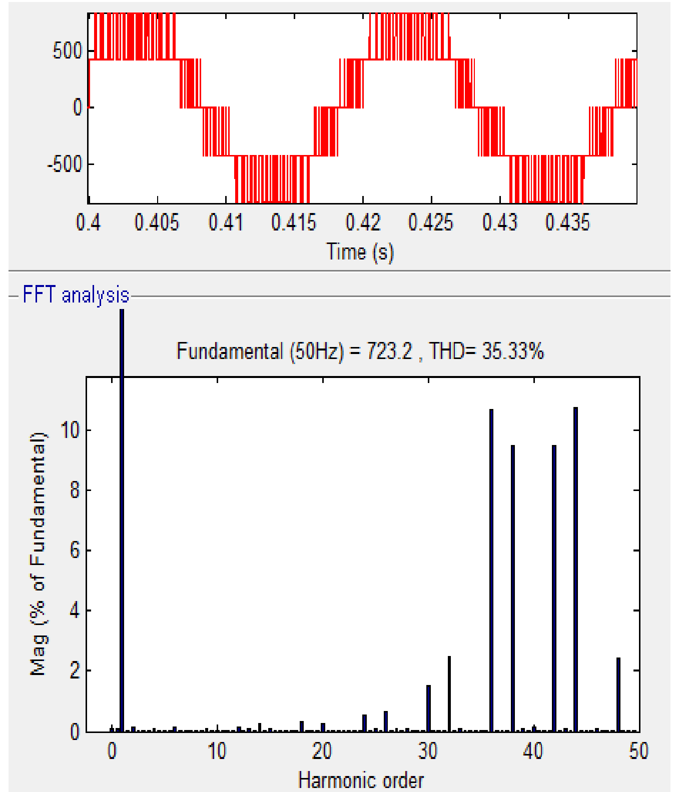

Fig.9 THD value of the five level cascaded H-bridge multilevel inverter using FFT analysis

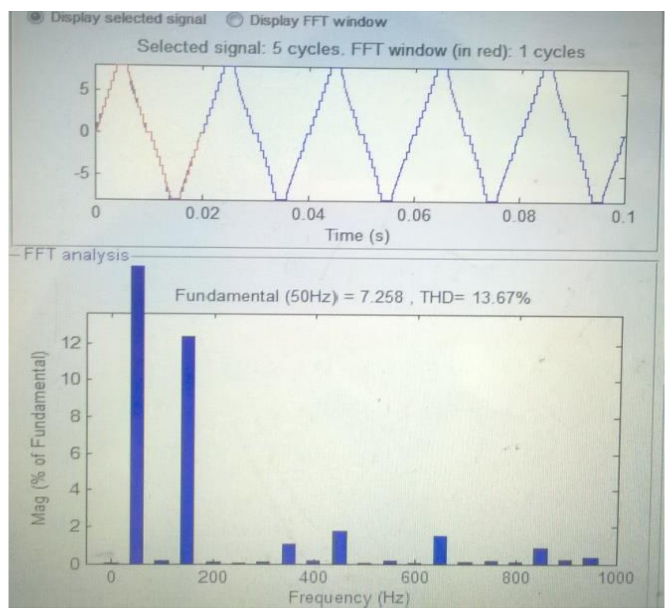

Fig.10 THD value of the seventeen level cascaded H-bridge multilevel inverter using FFT analysis

VI. CONCLUSION

Multilevel inverters have become an effective and practical solution for increasing the power and reducing harmonics of AC waveforms. This article is about the design and implementation of single-phase five-level Cascaded H-bridge multilevel inverter and seventeen-level inverter with RL load PWM modulation method. The simulation of 5-level and 17-level cascade H-bridge is made. Along with it, the harmonic analysis done. These multilevel inverters can be used FACTS devices in hybrid electric vehicle and electric drives. The simulation results show that the developed 17 level Cascaded H-bridge multilevel inverter has many merits, such as reducing the number of switches, lower EMI, lower harmonic distortion and achieved THD is 23.31%.

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