Abstract — The multilevel inverter utilization has been increased since the last decade. These new type of inverters are suitable in various high voltage and high power applications due to their ability to synthesize waveforms with better harmonic spectrum and faithful output. This paper presents an asymmetrical five level cascaded H-bridge multilevel inverter, using multicarrier pulse width modulation technique. And also comparison is made between multicarrier pulse width modulation and the embedded matlab function. The Simulation results are presented to prove that THD is reduced with the multicarrier modulation. This topology also reduces the number of switches and also the cost. From the results, the proposed inverter provides higher output quality with relatively lower power loss as compared to the other conventional inverters with the same output quality.

Index Terms — Cascaded H-bridge multilevel inverter (CHB), embedded matlab function, multicarrier pulse-width modulation, total harmonic distortion (THD).

I. INTRODUCTION

Demand for high-voltage, high power converters capable of producing high-quality waveforms while utilizing low voltage devices and reduced switching frequencies has led to the multilevel inverter development with regard to semiconductor power switch voltage limits. Multilevel inverters include an array of power semiconductors and capacitor voltage sources, the output of which generate voltages with stepped waveforms. The commutation of the switches permits the addition of the capacitor voltages, which reach high voltage at the output, while the power semiconductors must withstand only reduced voltages. The most attractive features of multilevel inverters are as follows:

1) They can generate output voltages with extremely low distortion and lower dv/dt.
2) They draw input current with very low distortion.
3) They generate smaller common mode (CM) voltage, thus reducing the stress in the motor bearings. In addition, using sophisticated modulation methods, CM voltages can be eliminated.
4) They can operate with a lower switching frequency.

The multilevel inverter has been implemented in various applications ranging from medium to high-power levels, such as motor drives, power conditioning devices, also conventional or renewable energy generation and distribution. The different multilevel inverter structures are cascaded H-bridge, diode clamped and flying capacitor multilevel inverter [4]. Among the three topologies, the cascaded multilevel inverter has the potential to be the most reliable and achieve the best fault tolerance owing to its modularity, a feature that enables the inverter to continue operating at lower power levels after cell failure. Modularity also permits the cascaded multilevel inverter to be stacked easily for high power and high-voltage applications. The cascaded multilevel inverter typically comprises several identical single phase H-bridge cells cascaded in series at its output side. This configuration is commonly referred to as a cascaded H-bridge, which can be classified as symmetrical if the dc bus voltages are equal in all the series power cells, or as asymmetrical if otherwise. In an asymmetrical CHB, dc voltages are varied to produce more output levels. In this paper, we are using two modulations, one is the multicarrier phase shifted modulation and other is the embedded matlab function and THD level is compared.

II. FIVE LEVEL CASCADED H-BRIDGE MULTILEVEL INVERTER

A. Conventional cascaded H-bridge multilevel inverter

Fig.1 shows a five level cascaded H-bridge multilevel inverter. The converter consists of two series connected H-bridge cells which are fed by independent voltage sources. The outputs of the H-bridge cells are connected in series such that the synthesized voltage waveform is the sum of all of the individual cell outputs. The output voltage is given by

\[ V = V_1 + V_2 \]

Where the output voltage of the first cell is labeled \( V_1 \) and the output voltage of the second cell is denoted by \( V_2 \). There are five level of output voltage ie 2V, V, 0, -V, -2V. The main advantages of cascaded H-bridge inverter is that it requires least number of components, modularized circuit and soft switching can be employed. But the main disadvantage is that when the voltage level increases, the number of switches increases and also the sources, this in effect increases the cost and weight. The cascaded H-bridge multilevel inverters have been applied where high power and power quality are essential, for example, static synchronous compensators, active filter and reactive power compensation applications, photo voltaic power conversion, uninterruptible power supplies, and magnetic resonance imaging. Furthermore, one of the growing applications for multilevel motor drive is electric and hybrid power trains.
B. Modified cascaded H-bridge multilevel inverter

Fig 2 shows the new cascaded five level H bridge multilevel inverter [6]. One switching element and four diodes added in the conventional full-bridge inverter are connected to the centre tap of dc power supply. Proper switching control of the auxiliary switch can generate half level of dc supply voltage. It has five output voltage levels that is V, V/2, 0, -V/2, -V. For getting the output voltage V the switches S1S2 need to be turned on. Similarly for output voltage V/2 switches S3S4 need to be turned on, for 0 either S1S2 or S3S4 need to be turned on; for –V/2 switches S2S5 need to be turned on; for –V switches S2S3 need to be turned on. The switching combinations are shown in Table 1.

C. PWM modulation

In this topology, for generating the switching pulses multilevel inverter with multicarrier modulation [3] and embedded matlab function are used. In the multicarrier modulation, the amplitude and frequency of all triangular carriers are the same as well as the phase shifts between adjacent carriers. Figure 3 and 4 shows multicarrier phase shifted pwm and embedded matlab function.

### Table 1

<table>
<thead>
<tr>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>S4</th>
<th>S5</th>
<th>Output voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON</td>
<td>OFF</td>
<td>OFF</td>
<td>ON</td>
<td>OFF</td>
<td>V</td>
</tr>
<tr>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>ON</td>
<td>ON</td>
<td>V/2</td>
</tr>
<tr>
<td>Or</td>
<td>Or</td>
<td>ON</td>
<td>Or</td>
<td>Off</td>
<td>0</td>
</tr>
<tr>
<td>ON</td>
<td>ON</td>
<td>OFF</td>
<td>OFF</td>
<td>ON</td>
<td>-V/2</td>
</tr>
<tr>
<td>OFF</td>
<td>ON</td>
<td>OFF</td>
<td>OFF</td>
<td>ON</td>
<td>-V</td>
</tr>
</tbody>
</table>

III. SIMULATION AND RESULTS

The circuit was simulated with R load. Figure 5 shows the circuit arrangement with multicarrier modulation. Figure 6 and 7 shows the output waveform of five level cascaded multilevel inverter with multicarrier modulation and embedded matlab function. A THD analysis was done for comparing to the traditional multilevel inverter.
and the result obtained is as shown in figure 8 and 9. A comparison of the multicarrier modulation and embedded matlab function is presented in table 2.

**TABLE 2: COMPARISON OF THD VALUES**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Multicarrier modulation</th>
<th>Embedded matlab function</th>
</tr>
</thead>
<tbody>
<tr>
<td>THD (%)</td>
<td>28.83</td>
<td>30.05</td>
</tr>
</tbody>
</table>

**IV. CONCLUSION**

In this paper, a five level cascaded H-bridge multilevel with multicarrier pulse width modulation and embedded matlab function, is presented. The simulation results show that the total harmonic distortion is low for multicarrier modulation method. The total harmonic distortion can be further reduced by using filter circuit. This circuit also reduces the number of switches and sources.

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REFERENCES


