A COMPARATIVE STUDY OF THREE LEVEL INVERTER USING VARIOUS TOPOLOGIES

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Abstract: The power electronics device is used control and convert electrical energy. This paper introduces a comparative study of three level inverter using various topologies. The main classifications of inverters are single level and multilevel inverter. Three level inverter can be modelled using various topologies like cascaded H Bridge, diode clamped and flying capacitor multilevel inverters. A multi-level inverter utilized for multipurpose applications, like active power filters, static VAR compensators and motor drives in sinusoidal and trapezoidal current applications. The main drawbacks of multilevel inverters are isolated power supplies needed for each one of the stages of the multi-converter and it’s also lot harder to build, more expensive, harder to control in software. Improved power extracting methods are used to minimize the power demand and scarcity. To extract power from solar cells multilevel inverters are used. Comparing to other two topologies cascaded H bridge is widely used. Since cascaded H Bridge give complete output of the input as we provided.

I. INTRODUCTION

Multilevel inverters are popularly used for very high voltage and high power applications. Multilevel inverters are of different types they are three level inverters, five level inverters etc. When ac loads are fed through inverters it required that the output voltage of desired frequency and magnitude can be achieved. By varying the input dc voltage and maintaining the gain of the inverter constant variable output voltage can be obtained. On the other hand, if the dc input voltage is fixed and it is not controllable, by varying the gain of the inverter output voltage can be obtained. Pulse-width-modulation (PWM) control is normally satisfied within the inverter. The inverter which produce output voltage zero or +V known as two level inverter. For high-power and high-voltage applications these two-level inverters have some limitations while operating at high frequency due to switching losses and constraints of device rating. Due to this reason multilevel inverters are advantageous over two levels. Without requiring higher rating on individual devices can increase power rating and increasing the number of voltage levels in the inverter. The unique structure of multilevel inverters is allows them to reach high voltages with low harmonics without the use of transformers or series-connected synchronized-switching devices. To synthesis a desired single-phase or three-phase voltage waveform multilevel converters are mainly used. Using several dc voltage sources desired multi-staircase output voltage is obtained. Solar cells, fuel cells, batteries and ultra-capacitors are the most common independent dc voltage sources used. Multilevel converters are mainly focused on medium and high-power conversion applications. Nowadays, three commercial topologies of multilevel voltage-source inverters are exist. They are, neutral point clamped (NPC), cascaded H-bridge (CHB), and flying capacitors (FCs).

Due to the modular topology cascaded multilevel inverter reaches the higher output voltage and power levels (13.8 kV, 30 MVA) and the higher reliability. Diode-clamped multilevel converters are widely used in conventional applications like high-power ac motor drive, conveyors, pumps, fans, and mills. They are also utilized in oil, gas, metals, power, mining, water, marine, and chemical industries. One of the most important applications of diode clamped multilevel inverters is considered as Back-to-back configuration for regenerative applications. Flying capacitor multilevel
converters have been used in the applications required high-bandwidth and high-switching frequency. Such as medium-voltage traction drives.

For sensitive loads and emergency communications needs high power and power quality, in such cases Cascaded H-bridge multilevel converters have been applied. Static synchronous compensators and reactive power compensators are the applications; photovoltaic power conversion, uninterruptible power supplies, and magnetic resonance imaging are the several examples. Ones of the growing applications for multilevel inverter electric motor drives and hybrid power trains. By increasing voltage levels the number of switches also will increase in number. As a result the voltage stresses and switching losses should increase and the circuit will become more complex.

By using the proposed topology efficiency can be improved by reducing the number of switches. In high power applications, to avoid distortion in the grid and to reach the maximum energy efficiency the harmonic content of the output waveforms has to be reduced as much as possible. When compared to the higher order harmonics, lower harmonics make more effects on the output. It is big challenge for any researcher to eliminate the third order harmonics using simple techniques, for a motor load its effects are high. This paper implements a new method to eliminate lower order harmonics. Selective Harmonics elimination technique is used. By using this technique third and fifth order harmonics are eliminated. To solve transcendental non linear equations numerical technique known as Newton Rapson method is adopted. By using this method Cascaded H-bridge seven level inverter is modelled and harmonic analysis is carried out and finally the hardware for the proposed topology is implemented and experimental results are presented.

II. THREE LEVEL INVERTER

Three level inverter topology, also known as Neutral Point Clamped (NPC) inverter. Compared to two level inverters, three- level inverter offers several advantages such as smaller output voltage steps and provides the cleaner output waveform. And having an effective switching frequency twice that of the actual switching frequency. In two level inverter the components will be smaller and less costly than three level inverter. Topology traditionally has been used for medium voltage drives both in industrial and other applications. Three level inverter can use various topologies like cascaded h bridge, diode clamped and flying capacitor.

III. MULTILEVEL INVERTER TOPOLOGIES

The basic three types of multilevel inverter topologies are;
1. Diode clamped multilevel inverter
2. Flying capacitor multilevel inverter
3. Cascaded multilevel inverter

IV. DIODE-CLAMPED MULTILEVEL TOPOLOGY

Due to capacitor voltage balancing issues, the diode-clamped inverter implementation has been mostly limited to the three levels. Because of industrial developments over the past several years, the three level inverter is now used extensively in industry applications. Although most
applications are medium-voltage, a three-level inverter for 480V. But the structure is more complicated than the two-level inverter, the operations straightforward and well known. In summary, each phase node can be connected to any node in the capacitor bank. Connection of the phase to junctions can be accomplished by switching both transistors are off and on. These states are the same as the two-level inverter yielding a line-to-ground voltage. It is mainly uses diode to provide multiple voltages along with capacitor bank which are in series. Diode transfers a limited amount of voltage, thereby reducing the stress on other electrical devices. Maximum output voltage is half of the input dc voltage.

![Diode clamped multilevel inverter](image)

**APPLICATION**

- Static VAR compensation
- Variable speed motor drives
- High voltage system interconnections
- High voltage DC and AC transmission lines

**V. FLYING CAPACITOR MULTILEVEL TOPOLOGY**

The flying capacitor multilevel topology considered to be the most serious alternative to the diode clamped topology. Compared to neutral point clamped converters a high number of auxiliary capacitors are needed. The main concept of this inverter is to use capacitors. It is series connection of capacitor clamped switching cells. Its operation is similar to diode clamped multilevel inverter. Clamping diodes are not required. The structure of this inverter is similar to that of the diode-clamped inverter except that instead of using clamping diodes, the inverter uses capacitors in their place. The circuit topology of the flying capacitor multilevel inverter is shown in Fig. This topology has a ladder structure of dc side capacitors, where the voltage on each capacitor differs from that of the next capacitor. The voltage increment between two adjacent capacitor legs gives the size of the voltage steps in the output waveform.

![Flying capacitor multilevel inverter](image)
VI. APPLICATIONS

- Induction motor control using DTC (Direct torque control) circuit.
- Static VAR generation.
- Both the ac-dc and dc-ac conversion application.
- Sinusoidal current rectifiers

VII. CASCADED INVERTER WITH SEPARATE DC SOURCE

This type of converter does not need any transformer clamping diodes, or flying capacitors; each bridge converter generates three levels of voltages. For a three-phase configuration, the cascaded converters can be connected in star or delta. This inverter is nothing but series connection of single connection of single phase inverter with separate dc source. This inverter can be avoiding the extra clamping diodes or voltage balancing capacitor. Each separate dc source (SDCS) is connected to a single-phase full-bridge, or H-bridge, inverter. Each inverter level can generate three different voltage outputs, \(+V_{dc}\), 0, and \(-V_{dc}\).

![Cascaded multilevel inverter](image)

Fig: 4 Cascaded multilevel inverter

APPLICATIONS

- Motor drives
- Active filters
- Electric vehicle drives
- DC power source utilization
- Static VAR compensator
- Interfacing with renewable energy source

Table 2.1: Comparison of different multilevel inverter topology

<table>
<thead>
<tr>
<th>Topologies</th>
<th>Power semiconductor switches</th>
<th>Clamping diode per phase</th>
<th>Bus capacitor per phase</th>
<th>Balancing capacitor per phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIODE CLAMPED</td>
<td>2(m-1)</td>
<td>(m-1)(m-2)</td>
<td>(m-1)</td>
<td>0</td>
</tr>
<tr>
<td>FLYING CAPACITOR</td>
<td>2(m-1)</td>
<td>0</td>
<td>(m-1)</td>
<td>(m-1)(m-2)/2</td>
</tr>
<tr>
<td>CASCADED H BRIDGE</td>
<td>2(m-1)</td>
<td>0</td>
<td>(m-1)/2</td>
<td>0</td>
</tr>
</tbody>
</table>
VIII. CONCLUSION

The general concept of multilevel power conversion was introduced more than twenty years ago. However, most of the development in this area has occurred over the past five years. Furthermore, each year seems to bring even more publications than the previous. Besides the mainstream power electronics conferences and journals, multilevel power conversion is also showing up in power systems and electronics societies. Despite the rapid growth of this area in recent years and the increasing number of innovations introduced each year, there is still much more that can be done. The author has contributed to this field over the past ten years and encourages other researchers to expand this work in the context of other, closely related, research areas alluded to herein. Although numerous topologies and modulation methods were discussed, several more can be found in the references and in the literature. An additional goal of this monograph was to introduce concepts related to reducing the number of isolated voltage sources and sensors. This can be important in the high power quality cascaded multilevel inverters which require several voltage sources and knowledge of the dc voltage levels. Applications of the cascaded multilevel inverter include naval ship propulsion which necessitates high power quality.

REFERENCES