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Study of Multilevel Inverter Topologies and Modulation Techniques

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ABSTRACT Inverter is a device used to convert direct current into alternating current , inverters are mainly classified into single level (conventional) and multilevel inverter. This single level and multilevel inverter has different type of topology namely H bridge inverter, diode clamped inverter, capacitor clamped, cascaded multicell inverter etc. The main difference between single level inverter and multilevel inverter is when comparing the both we get more efficiency from multilevel inverter. Multilevel inverters produce output in different levels, the example for multilevel inverters are two level, three level etc.When the level is increased we get more efficient output waveform for both current and voltage with low harmonic distortion.

I.INTRODUCTION

Numerous industrial applications have begun to require higher power apparatus in recent years. Some medium voltage motor drives and utility applications require medium voltage and megawatt power level. For a medium voltage grid, it is troublesome to connect only one power semiconductor switch directly. As a result, a multilevel power converter structure has been introduced as an alternative in high power and medium voltage situations. A multilevel converter not only achieves high power ratings, but also enables the use of renewable energy sources. Renewable energy sources such as photovoltaic, wind, and fuel cells can be easily interfaced to a multilevel converter system for a high power application.

The concept of multilevel converters has been introduced since 1975. The term multilevel began with the three-level converter. Subsequently, several multilevel converter topologies have been developed. However, the elementary concept of a multilevel converter to achieve higher power is to use a series of power semiconductor switches with several lower voltage dc sources to perform the power conversion by synthesizing a staircase voltage waveform. Capacitors, batteries, and renewable energy voltage sources can be used as the multiple dc voltage sources. The commutation of the power switches aggregate these multiple dc sources in order to achieve high voltage at the output; however, the rated voltage of the power semiconductor switches depends only upon the rating of the dc voltage sources to which they are connected.

II. MULTI INVERTER TOPOLOGY

Three basic type of multilevel inverter topologies are

1. Cascaded H bridge multilevel inverter
2. Diode clamped multilevel inverter
3. Flying capacitor multilevel inverter

III a. Cascaded H bridge inverter

In Cascaded H-bridge multilevel inverter topology consist of H- bridges which are connected in series. The output of a cascaded H bridge inverter become more sinusoidal with increase in the number of H bridge,(n-1)/2 identical H- bridges are used in n topology . There each individual H-bridge consist of separate dc source. The resulting phase voltage is synthesized by the addition of the voltages generated by the different cells. For a 3-level cascaded inverter each single-phase full-bridge inverter generates three output voltage +Vdc, 0, -Vdc (zero, positive dc voltage,

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and negative dc voltage). This can be possible by connecting the capacitors sequentially to the ac side through the power switches. The resulting output ac voltage swings from -Vdc to +Vdc with three levels, -2Vdc to +2Vdc with five-level and - 3Vdc to +3Vdc with seven-level inverter.

For a cascaded H bridge inverter the number of power electronic switches required is 2(m-1) where m is the level of output voltage. Clamping diodes per phase for a cascaded H bridge inverter is zero and also the main advantage of cascaded H bridge inverter is that the voltage unbalancing is very small and hence balancing capacitor per phase is zero. Due to this feature cascaded H bridge inverter is most commonly used over other type of inverters. The level of H bridge inverter can be obtained from the equation

M=2s+1

Where , s is the number of dc source

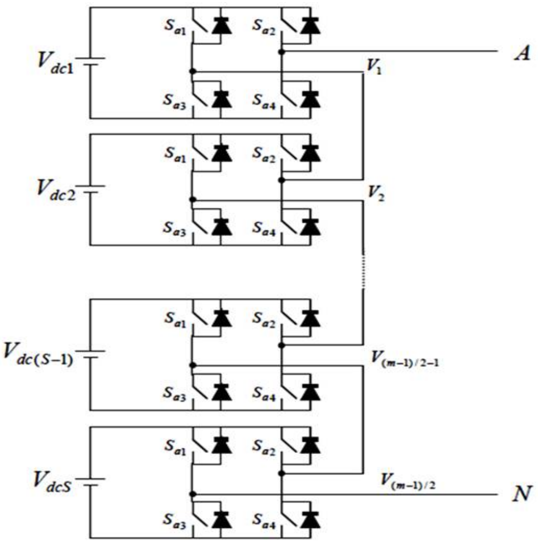

Fig 1: Single phase Cascaded H bridge inverter

The main application of cascaded H bridge inverters is motor drive system, PV, fuel cell battery etc.

Advantages

- The number of possible output voltage levels is more than twice the number of dc sources (m = 2s + 1).
- The manufacturing process to be done more quickly and cheaply in the case of H bridge inverter due to modularized layout and packaging

Disadvantages

- Each H bridge or full bridge inverter requires separate dc source

III b. Diode clamped multilevel inverter

This converter is proposed by Nabae, Takahashi, and Akagi in 1981 as a three level inverter. After that in 1990s several articles are published about the experimental results for four-, five-, and six-level diode-clamped converters for such uses as static VAR compensation, variable speed motor drives, and high- voltage system interconnections. Each of the three phases of the inverter shares a common dc bus, which has been subdivided by five capacitors into six levels. The voltage across each capacitor is Vdc, and the voltage stress across each switching device is limited to Vdc through the clamping diodes.

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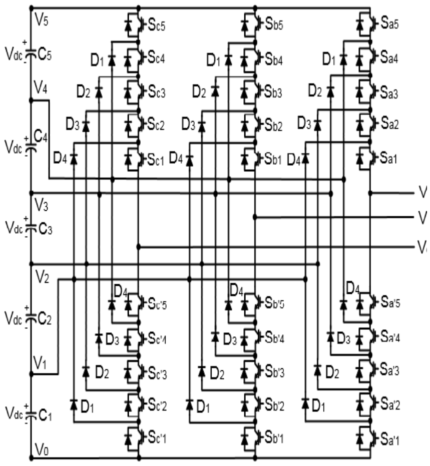

Fig 2 :Diode clamped multilevel inverter

Advantages

- High voltage back to back interconnection possible.
- For fundamental frequency switching efficiency is high.

Disadvantages

- Number of clamping diodes are high
- Output is half of the input voltage

<u>APPLICATION</u>

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

III c. Flying capacitor type multilevel inverter

Flying capacitor inverter is similar to that of the diode clamped inverter the only one difference is that instead of diode here capacitors are used. This multilevel inverter was invented by Meynard and Foch in 1992.

APPLICATION

- Induction motor control using DTC (Direct torque control) circuit.
- Static VAR generation.

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- Both the ac-dc and dc-ac conversion application.
- Sinusoidal current rectifiers

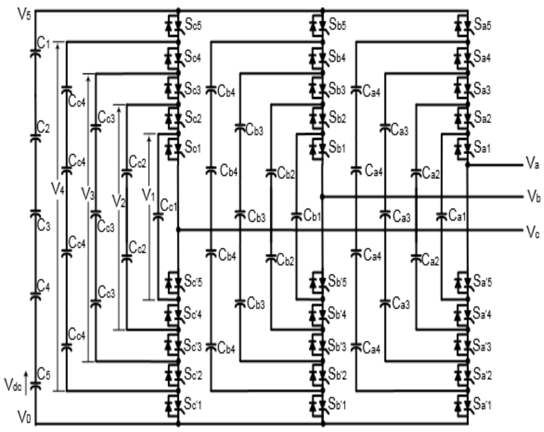

Fig 3:Flying capacitor multilevel inverter

IV. MODULATION TECHNIQUES

For different load requirement the output voltage of the inverter needs to be varied.When ever the input dc varies the output voltage can change.Hence this variation needs to be compensated.In case of motor drives the ratio of voltage to frequency $(\frac{v}{f})$ maintaned to be constant.Similarly ,in UPS the output voltage of inverter is to be regulated.This all the reasons indicate that the output voltage of the inverter is to be controlled.The pulse width modulation techniques are mainly used for voltage control.These techniques are most efficient and they control the drives of the switching devices.

The mainly used PWM techniques are

1. Single pulse width modulation
2. Multiple pulse width modulation
3. Sinusoidal pulse width modulation
4. Modified sinusoidal pulse width modulation
5. Phase displacement modulation

IV a. Single pulse width modulation

In single pulse-width modulation control, there output voltage is controlled by varying the only one pulse per half cycle. The single pulse-width modulation reference signal is converted to the square wave signal. This process is obtained by inter the reference signal to the zero-crossing circuit witch consider the positive part of the input signal is positive part of the output signal(square wave) and the negative part of the input signal is negative part of the output signal .

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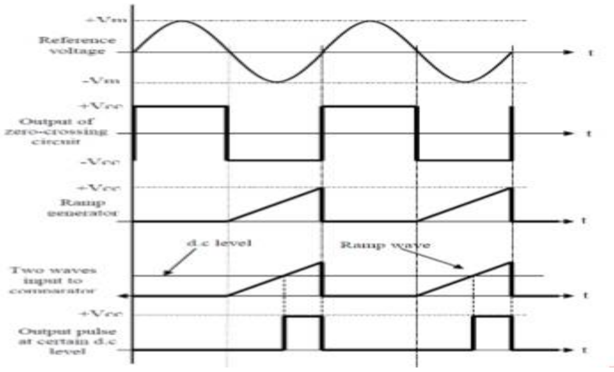

Fig: Single pulse width modulation

IV b. Multiple pulse width modulation

The harmonic content can be reduced by using several pulses in each half-cycle of output voltage. The number of pulses per half cycle is found from p=$\frac{fc}{2fo}$.

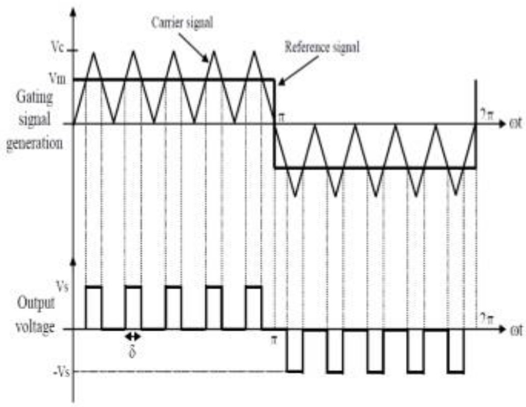

Fig:Multiple pulse width modulation

IV c Sinsoidal pulse width modulation

Instead of maintaining the width of all pulses the same, the width of each pulse is varied in proportion to amplitude of a sine wave.

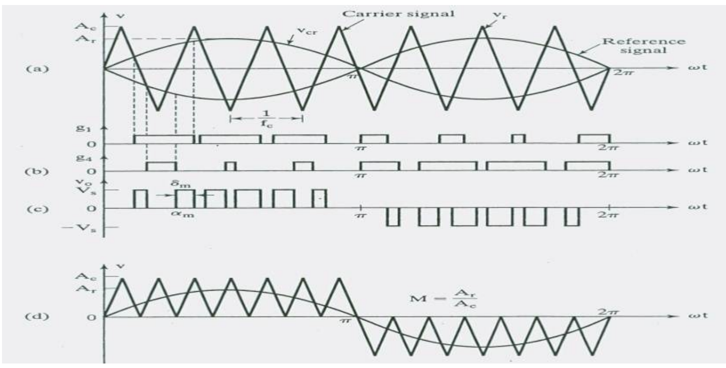

Fig:Sinusoidal pulse width modulation

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V. CONCLUSION

SI NO	TOPOLOGY	DIODE CLAMPED	FLYING CAPACITOR	CASCADED
1	Powersemiconductor switches	2(m-1)	2(m-1)	2(m-1)
2	Clamping diodes per phase	(m-1)(m-2)	0	0
3	DC bus capacitor	(m-1)	(m-1)	$\frac{(m-1)}{2}$
4	Balancing capacitors/phase	0	(m-1)(m-2)/2	0
5	Voltage unbalacing	average	high	Very small
6	Applications	Motordrive system,STATCOM	Motordrive system,STATCOM	Motordrive,pv ,Fuel cells

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