A Review of Cascaded H-Bridge Multilevel Inverter: Control Techniques with comparison between open loop and closed loop techniques.

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Abstract: **Multilevel inverters (MLI) have largely attracted the attention of academic and industries. The demand of MLI has increased recently as it is capable of generating quality waveform by using low voltage devices, reduced switching frequencies and reduced harmonics content of the output power. There are several topologies discussed and analyzed in literature in past decades. In this paper, I have considered Cascaded H-Bridge Multilevel inverter as a reference for explaining control techniques for Cascaded H-Bridge Multilevel Inverter. Here I have explained the open loop and closed loop techniques.**

1. INTRODUCTION

Multilevel inverters have gained more attention in high power applications because it has got many advantages. It can realize high voltage and high power output by using semiconductor switches without the use of transformer and dynamic voltage balance circuits. When the number of output levels increases, harmonic content in the output voltage and current as well as electromagnetic interference decreases.

The basic concept of a multilevel inverter is to achieve high power by using a series of power semiconductor switches with several lower dc voltage sources to perform the power conversion by synthesizing a staircase voltage waveform. [1]

2.FIVE LEVEL CASCADED H-BRIDGE MLI STRUCTURE (Single Phase)

Conventional cascaded multilevel inverters are one of the most important topologies in the family of multilevel and multi-pulse inverters. The cascade topology allows the use of several levels of DC voltages to synthesize a desired AC voltage. The DC levels are considered to be identical since all of them are fuel cells or photovoltaics, batteries, etc.. It requires least number of components compared to diode-clamped and flying capacitors type multilevel inverters and no specially designed transformer is needed as compared to multi pulse inverter.

Since this topology consists of series power conversion cells, the voltage and power level may be easily scaled. The concept of this inverter is based on connecting H-bridge inverters in series to get a sinusoidal voltage output. The output voltage is the sum of the voltage that is generated by each cell. The number of output voltage levels are 2n+1, where n is the number of cells. [2]

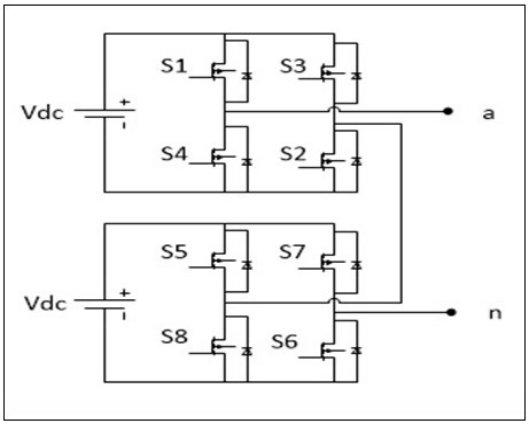

Fig: -1. Single Phase Five Level Cascaded Multilevel Inverter circuit diagram.

3. CIRCUITTOPOLOGY CASCADED H-BRIDGE MLI (3phase)

Cascaded H-bridge multilevel inverter (CHBMLI) is different in several aspects from Neutral-Point Clamped multilevel inter (NPCMLI) and Capacitor Clamped multilevel inverter (CCMLI) on the approach to achieve voltage waveform at several levels. It uses cascaded inverters H-bridge DC-separated sources in the preparation of units.The H-bridge unit itself is CHBMLI three levels, where each additional unit cascaded to be extended with two levels of voltage inverter. In Fig-2, there are two H-bridge modules to create five variation voltage levels. [3]

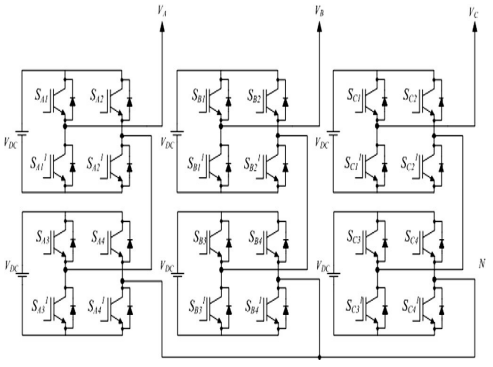

Fig 2. Three-phase five-level cascaded H-bridge multilevel inverter

4. CONTROL TECHNIQUE FOR CASCADE H-BRIDGE MLI

Multilevel inverters achieve high voltage switching through a series of work steps. One of the most important problems in the control of a multilevel inverter is to get a variable amplitude and frequency sinusoidal output using a simple control technique. The first impression of the multilevel converters is that a large number of switching may cause the switch configuration of complex topology. Many techniques are applied to the inverter topology. Control technologies can be divided into multi-PWM inverter technology and selective harmonic elimination sinusoidal PWM (SPWM), space vector PWM (SVM), and similar variations of the three main algorithms as seen in Fig-3. This section presents the methods and reviews some of the basic researches that have been done in this area. [3]

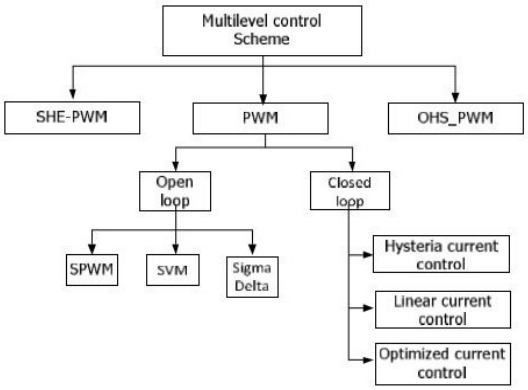

Fig-3. Classification of control schemes of multilevel inverter.

5. OPEN LOOPCONTROL OF MLI WITH PWM TECHNIQUES.

A. Sinusoidal Pulse-Width Modulation

The majority of PWM inverters used techniques based on the sampling method. Control technology is the most popular method of pulse width modulation sine adapter's two traditional levels. The term sinusoidal PWM refers to the production of the PWM output signal with a sine wave as a modulation signal. The sinusoidal PWM technology is commonly used in industrial applications and abbreviated here as SPWM. Frequency of the modulating wave determines the frequency of the outputvoltage. The enlargement of the height of the modulation index of the waveform determines the composition turn control of the RMS value in the output voltage. [3]

B. Space Vector PWM (SVPWM)

The SVPWM technique is widely used for bi-level PWM converter control, which can be integrated to multilevel inverters. These vector diagrams are universal regardless of the topology of multilevel converter. As a result, it can be implemented for diode-clamped, capacitor-clamped, or cascaded converters. The advantages of implementing the Space-vector PWM method are: i. Good utilization of DC-link voltage and low current ripple, and ii. Digital signal processing (DSP) can be interfaced and executed easily. Moreover, there is less complexity in using the control system. A conceptually different control method for multilevel converters, based on the space-vector theory, has been introduced, which is known as space vector control (SVC). [3]

6. CLOSED LOOP CONTROL OF MULTILEVEL INVERTER

In this part of research, the closed loop control of cascaded multilevel inverter with PI and FLC are studied and simulated. The output voltage of the cascaded inverter is compared with reference sinusoidal waveform and the error is given to the PI controller to generate the gating signals. The idea of fuzzy logic controller introduced by Prof. Zadeh in 1965 has become popular recently. The Fuzzy Logic Controller (FLC) uses partial assembly similar to human thinking function rather than using crisp membership function. According to Fig-4, the procedure of basic controllers design is same for both; however, the characteristic features are exclusively described for each controller. The design of fundamental steps follows the input and output parameters. There is a variety of assembly functions and modeling of control rules. There are also possible inferences from assembly functions and control rules.

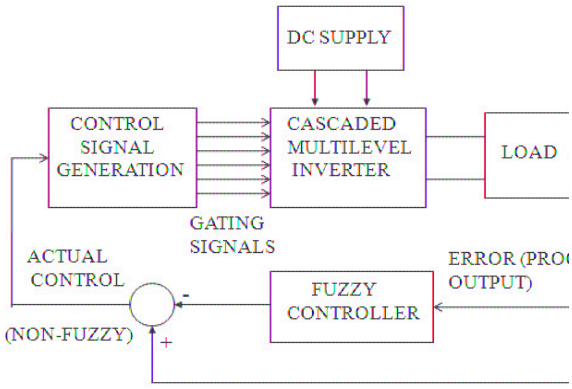

Fig-4 Structure of inverter topology with fuzzy controller

7. CONCLUSION

In this paper,Cascade H-bridge inverter that have been discussed and analyzed considering all parameters and conditions.I have explained the control techniques for Cascade H-Bridge inverter.And I have analyzed the result for Cascade H-Bridge with the open loop and closed loop techniques. I have inferred that the total harmonic distortion is reduced by closed loop control with fuzzy controller. Also, all the lower order and higher order harmonics are eliminated using SPWM technique. It is also inferred that for low values of modulation indices, the fuzzy controller gives better THD profile and for higher values of modulation indices, the PI controller offers low THD.

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