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Comparative Study of NPC and Cascaded Converters Topologies

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Abstract— **Multilevel converters have many advantages which are the capacity to generate a very good quality of waveforms, the reduced switching frequency, the low energy loss and the low effort on power devices. They are used in different power electronic applications including statics synchronous compensators (STATCOM). This paper presents a comparative study of Neutral Point Clamped (NPC) and H-bridge cascaded converters. A theoretical analysis of NPC and cascaded multilevel is presented. The generalized study for N levels converters topologies is derived. The theoretical study is validated using computer simulation in Matlab/Simulink/SimpowerSystems environment. Output voltage and total harmonic distortion are compared.**

Key words- Multilevel converters, NPC converter, H cascaded converter, static synchronous compensator

I. Introduction

The interest for multilevel converters comes from their capacity to provide higher power, to generate good quality of waveforms, to operate at low switching frequency with low loss of energy and the low effort on statics devices [1], [2]. Among multilevel converters topologies, there are the Neutral Point Clamped (NPC) converter, the cascaded H-bridge multilevel converter and the imbricated cell multilevel converter [1], [3].

For the NPC converters, the number of levels can be defined as:

$$N = \frac{m}{2} + 1 \tag{1}$$

where m is the number of switches per phase.
For the cascaded H-brigde multilevel converters, the number of levels is determinate by:

$$N = 2NH + 1 \tag{2}$$

where NH is the number of bridges per phase.

In a general, the number of levels is determinate by:

$$N = P + 1 \tag{3}$$

where P is the number of complementary pairs of switches per phase.

The NPC converter and cascaded H-bridge multilevel converter are most widespread topologies in STATCOM applications. This paper presents a comparative study of Neutral Point Clamped (NPC) and H-bridge cascaded converters. A theoretical analysis of NPC and cascaded multilevel is presented. The generalized study for N levels converters topologies is derived. Output voltage and total harmonic distortion are compared.

II. Theoretical Analysis

A. NPC Converter

Three phase NPC converter with five levels of voltage is shown on Figure 1. Each phase is made of eight controlled switches which are unidirectional in voltage and bidirectional in current and six maintaining diodes connected along the continued bus. The converter is powered by a DC source V, connected to four capacitors of equal values.

Our study is limited to a leg of NPC converter with five levels. The voltage values v_{ao} are determined for different operating conditions and the switching sequences of the statics devices are presented. Five switching sequences can be identified:

- Sequence 1 (Figure 2-a) :

K_1, K_2, K_3 and K_4 are on and K_5, K_6, K_7 and K_8 are off. The point a is connected to the positive terminal of the first voltage level $\frac{V}{4}$ and the point O is connected to the negative terminal