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Analysis and Comparison of Asymmetric H-Bridge Multilevel Inverter Topologies

Authors : Manel Hammami, Gabriele Grandi

Abstract : In recent years, multilevel inverters have become more attractive for single-phase photovoltaic (PV) systems, due to their known advantages over conventional H-bridge pulse width-modulated (PWM) inverters. They offer improved output waveforms, smaller filter size, lower total harmonic distortion (THD), higher output voltages and others. The most common multilevel converter topologies, presented in literature, are the neutral-point-clamped (NPC), flying capacitor (FC) and Cascaded H-Bridge (CHB) converters. In both NPC and FC configurations, the number of components drastically increases with the number of levels what leads to complexity of the control strategy, high volume, and cost. Whereas, increasing the number of levels in case of the cascaded H-bridge configuration is a flexible solution. However, it needs isolated power sources for each stage, and it can be applied to PV systems only in case of PV sub-fields. In order to improve the ratio between the number of output voltage levels and the number of components, several hybrids and asymmetric topologies of multilevel inverters have been proposed in the literature such as the FC asymmetric H-bridge (FCAH) and the NPC asymmetric H-bridge (NPCAH) topologies. Another asymmetric multilevel inverter configuration that could have interesting applications is the cascaded asymmetric H-bridge (CAH), which is based on a modular half-bridge (two switches and one capacitor, also called level doubling network, LDN) cascaded to a full H-bridge in order to double the output voltage level. This solution has the same number of switches as the above mentioned AH configurations (i.e., six), and just one capacitor (as the FCAH). CAH is becoming popular, due to its simple, modular and reliable structure, and it can be considered as a retrofit which can be added in series to an existing H-Bridge configuration in order to double the output voltage levels. In this paper, an original and effective method for the analysis of the DC-link voltage ripple is given for single-phase asymmetric H-bridge multilevel inverters based on level doubling network (LDN). Different possible configurations of the asymmetric H-Bridge multilevel inverters have been considered and the analysis of input voltage and current are analytically determined and numerically verified by Matlab/Simulink for the case of cascaded asymmetric H-bridge multilevel inverters. A comparison between FCAH and the CAH configurations is done on the basis of the analysis of the DC and voltage ripple for the DC source (i.e., the PV system). The peak-to-peak DC and voltage ripple amplitudes are analytically calculated over the fundamental period as a function of the modulation index. On the basis of the maximum peak-to-peak values of low frequency and switching ripple voltage components, the DC capacitors can be designed. Reference is made to unity output power factor, as in case of most of the grid-connected PV generation systems. Simulation results will be presented in the full paper in order to prove the effectiveness of the proposed developments in all the operating conditions.

Keywords : asymmetric inverters, dc-link voltage, level doubling network, single-phase multilevel inverter
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