TUTORIAL ON LOW FREQUENCY MODULATION OF MODULAR MULTILEVEL CONVERTERS

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Abstract

Multilevel Converters (MLC) are gaining popularity in many areas of energy conversion including Renewable Energy Systems, Distributed Generation, Smart Grids, E-Transportation, Electrical Drives for Industry. They are capable to overcome the voltage limits imposed by the adopted power devices (SCR, IGBT, MOSFET) and reducing voltage and current harmonics content and power losses. Their characteristics depend on their architecture and the adopted modulation algorithm, the latter imposing, step-bystep, the desired switching patterns to output power devices. After a brief resume of the main modulation methods, the speech will focus on Selective Harmonic Modulation algorithms (SHE) operating at the fundamental frequency and capable to eliminate some specific frequencies from the outputs. With conventional SHE methods, a set of switching angles is computed off-line (e.g. using Simulink) and then stored in a look-up table (LUT), that is implemented inside the internal memory of the digital control system. The LUT is scanned in real-time by the digital controller during converter operation, which returns the most appropriate pre-calculated set of conduction intervals/angles. The determination of the switching angles is quite complex and time-consuming and it is often achieved using artificial intelligence methods, which cannot be performed in real-time and require large amounts of memory space, necessary to store the numerous outputs in LUT. A reduction of the number of pre-computer sets of angles brings to the low resolution of commutation angles and poor THD, moreover, it is not flexible with closed-loop operations.
Analytical methods, instead, require an exact mathematical problem formulation but brings relatively complex equations, which can be computed in real-time using conventional hardware. They don't need large memory spaces and offer superior selective harmonic elimination capabilities. Analytical approaches can also lead to selective harmonics mitigation,

which, although not eliminating any specific harmonic, can bring to better total harmonics distortion. After a theoretical discussion on the fundamentals of modulation algorithms with analytical methods, the speech will introduce and discuss some methods developed for and implemented with cascaded H-Bridge multilevel converters. The ad-hoc modular multilevel converter architecture developed by DigiPower Ltd. will be also discussed before presenting some simulation and experimental results.