Modulation Techniques for Modular Multilevel Converters in High-Voltage Direct Current Transmission Systems

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Modular multi-level converters are the new “hearts” of future high-voltage direct current transmission (HVDC) systems since they are able to “pump” output voltage level to a large number effectively as compared to what current voltage sourced converters in HVDC can offer. The cascaded submodules of the converter perform self-contained functions of being inserted or being bypassed. Such a sequence of insert or bypass actions is resulted from modulation techniques applied to the converter.

A summarization of modulation techniques that have been used for voltage-sourced converters is presented first. Then two modulation techniques—a sinusoidal pulse-width modulation and a staircase modulation—are further examined and extended to modulate and control modular multi-level converters. In addition, simulation studies are conducted to prove an improvement of the output voltage quality benefited from using the staircase modulation over the sinusoidal pulse width modulation on both stand-alone voltage-sourced converter applications and applications in high-voltage direct current transmission systems.