

## **Abstract: Low switching frequency modulation techniques for renewable energy multilevel converters**

For renewable energy applications, cascaded H-bridge (CHB) multilevel inverters are highly appreciated, due to reduction of switching losses obtained by the application of low frequency modulation methods. Selective harmonic elimination (SHE) methods allow the use of low switching frequency and the elimination of certain low order harmonics maintaining the fundamental voltage at the desired level. Based on variable terms in the non linear SHE equations, the SHE methods can be classified as:

- 1) SHE pulse-width modulation (SHE-PWM),
- 2) SHE pulse-amplitude modulation (SHE-PAM).

In SHE-PWM methods only switching angles have regarded as degrees of freedom in the SHE equations. For a fixed number of levels, more angles are required to eliminate more harmonics; consequently switching frequency must be increased.

In SHE-PAM technique, the value of inverter DC voltage can be considered as an additional degree of freedom; the conventional equations are reformulated to obtain constant switching angles for a wide range of modulation index. In other words, the introduction of floating voltage levels contributes to effectively doubling the number of variables.

SHE technique requires the solution of a transcendental equations system which is not deterministic for a full range of modulation indices or operating points. Many mathematical iterative techniques have been proposed in the literature. They are computationally burdensome and require a good chose of initial values. It is difficult to converge to a solution for iterative methods and increasing the number of variables or dimensions, the possibility of divergence increases.

Based on the Groebner bases and symmetric polynomial theory, the SHE equations can be transformed to an equivalent canonical system which consists of algebraic equations. This method has not requirement on choosing initial values, it can find all the solutions and the solving procedure is simplified.

This talk focuses on the review of modulation techniques working at low switching frequency for renewable energy power converters. Particular attention is given to SHE-PWM and SHE-PAM techniques, highlighting benefits and drawbacks of each regarding total harmonic distortion (THD) of output voltage and current, system efficiency and cost.