Contribution ID: **237** Type: **Oral**

Multilevel Voltage Hysteresis Modulation and Control for High Voltage Modulators

Monday 19 June 2017 15:30 (15 minutes)

High voltage modulators (HVM) have been used widely for broadcast, medical, industrial and research applications. The most common modulation techniques for HVM are Pulsed Step Modulation, Coarse Step Modulation, PWM and their hybrid modifications.
All these methods require a presence of PI-controller with additional Feedforward loop in control system to estimate a modulation index or duty cycle at every step of discretization. Although all mentioned control algorithms have been used by engineers for a long time, there are still some disadvantages. For instance, low frequency pulsations of output voltage usually occur due to unbalance of DC-link voltages, variation in parameters of passive elements and deviations of duty cycles of series connected modules. Another drawback, especially in plasma research applications, is a strong correlation between parameters of PI-controller and load parameters. In case if plasma characteristics change rapidly and in wide range, then PI voltage controller is not capable of operating efficiently.
A novel Multilevel Voltage Hysteresis Modulation and Control (MVH-MC) technique is proposed, which can be applied to HVM with any number of series connected modules. This MVH-MC allows very accurate voltage regulation in a wide range of load parameters fluctuations. The output voltage is free of low frequency oscillations and its deviation from the reference value is always kept at the minimum preset value. The MVH-MC system performs a rotation of the modules at every switching period and the width of individual voltage pulses is adjusted automatically in such a way to maintain a minimum regulation error. There is no need in DC-link voltage regulation loops, because DC-link voltages are balanced by rotation technique, which is also ensured by reduced hysteresis frequency bandwidth using a parabolic shrinking of boundary levels.
The MVH-MC is planned to be used in 10kV/4kA Electrode Power Supplies of C-2W experiment at Tri-Alpha Energy Inc.

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Session Classification: Oral session 5 - Pulse Forming Networks and Alternate Technologies (part I) - Session Chair : John Mankowski

Track Classification: High Power Electronics