

## SYMBOLIC CALCULATIONS OF NATURAL VOLTAGE BALANCING DYNAMICS IN MULTILEVEL FLYING CAPACITOR CONVERTERS

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**Introduction.** While most of the past research addressed the analysis of natural voltage balancing in Flying Capacitor Converters (FCC) (Fig.1, 2) using frequency domain Fourier based methods, the authors attack the problem in time domain using appropriate averaging methods.

**Materials and methods.** Straight-forward but tedious time-averaging analytical calculations are required to find out balancing frequencies, time constants and overall average capacitor voltage natural balancing dynamics [1]. The natural balancing dynamics analysis procedure is automated by using Matlab symbolic calculation tool.

**Results and discussion.** The outcome of this research is a tool that outputs simple closed-form formulas revealing the dependences of FCC natural balancing dynamics (balancing frequencies and time constants) on switching frequency, capacitances, RL-load and modulation parameters.

**Conclusions.** It is demonstrated that suggested methodology for time domain analysis of natural voltage balancing dynamics is most adequate for multilevel capacitive single-leg and single-phase (H-bridge) converters. This approach delivers simple closed-form solutions for natural balancing frequencies, time constants and overall balancing dynamics thus providing an in-depth insight into natural balancing mechanisms and the influence of load and modulation parameters.

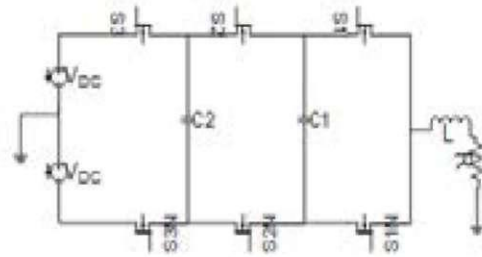


Fig.1. Single-leg 4-level FCC

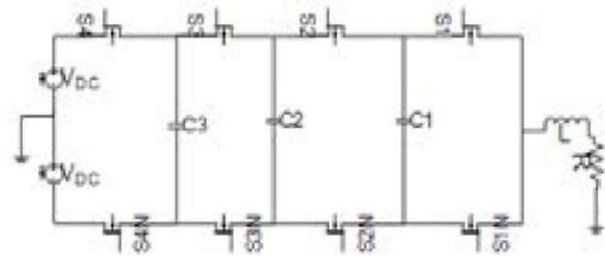


Fig.2. Single-leg 5-level FCC

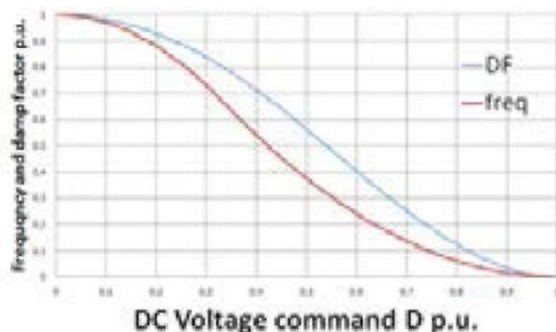


Fig.3. Balancing frequency and damping factor (DF) of 4-level FCC

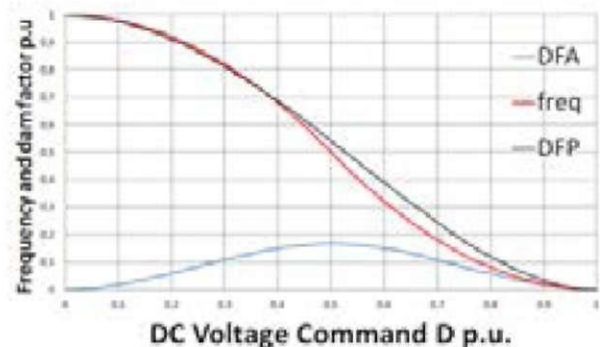


Fig.4. Balancing frequency and damping factors (DFA and DFP) of 5-level FCC

### References.

1. A. Ruderman and B. Reznikov, "Simple time domain averaging methodology for flying capacitor converter voltage balancing dynamics analysis," *Proc.IEEE Int. Symp. on Ind. Electr. (ISIE)*, July 2010, pp. 1064-1069.