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Modular, Highly Dynamic and Ultra-Low Ripple Arbitrary Current Source for Kicker Magnets and Plasma Research

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Various modern applications like fusion reactors for plasma generation, beam deflecting equipment in accelerators, equipment for magnetic resonance imaging (MRI) and test equipment for future HVDC breakers, require highly dynamic, high power pulsed current sources. Such current sources must provide a high current gradient combined with an ultra-low ripple and a stable operation under dynamically changing loads. Designing a flexible current source that could meet these requirements is challenging and requires a systematic approach when it comes to the choice of the converter topology and its control concept.

In previous work, a novel topology that could be used for such a current source was introduced. In short, a low voltage converter is used in series with a modular multilevel Marx-type converter in order to generate the required high output voltage levels. However, the applied relatively simple control concept, limited the dynamic performance of the topology and its robustness under load disturbances.

Therefore, an enhanced topology capable to produce high current pulses with high current gradients (> 15 A/µs) and ultra-low ripple (< 1 %) is presented in this paper, along with a novel control concept able to harness the full potential of the chosen topology. This ensures that the requirements are met without compromising neither the stability of the system during sudden load changes nor its precision at steady state due to parameter mismatches.

In the full paper, the operation principle of the system is described and the potential of the topology is identified. Simulation results of the system, controlled by an advanced control concept, verify the capabilities of the chosen topology and its control. Finally, a behavioral chaos-based DC arc model, with a frequency spectrum that matches the spectrum of a realistic DC arc, is presented in order to simulate the system's behavior when plasma is used as load.

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