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2P62 - A comprehensive design procedure for high voltage pulse power transformers

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Typical pulsed power applications cover the field as e.g. collision and fusion experiments or the generation of high temperatures, as well as the generation of X-rays in medical applications [1]. In these applications, pulsed power modulators are used for generating highly accurate high voltage pulses with very fast rise and fall times and pulse widths from microseconds to milliseconds. In order to produce such very fast rising voltage pulses, pulse transformer based modulator systems are utilized. The rise and fall times can be directly adjusted by the leakage inductance and the stray capacitance of the transformer. Therefore, the proposed design method combines calculation of parasitics with isolation design and dynamic voltage distribution design within the windings.
In the considered application, the required nominal pulse voltage amplitude is 44.2 kV with a pulse power of 4.42 MW, a pulse length of 5 us and a maximal rise time of 1us. In this paper, a comprehensive design procedure for high voltage pulse power transformers is presented. The procedure is based on the finite element method (FEM) and contains an electrical model, a magnetical model, a thermal model of the transformer and a procedure for the isolation design. In addition, to avoid over voltages within the winding, a model for the dynamic voltage distribution is included in the approach as well. For validation of the models and the design procedure, a prototype has been built and is tested under full load conditions. There, the main focus is on evaluating the parasitics, which are crucial for the shape of the output voltage pulse. Further, the isolation design will be proofed by high voltage impulse tests.

[1]···D.A.Gerber, “Ultra-Precise Short-Pulse Modulator for a 50 MW RF Output Klystron for Free-Electron Lasers,” Ph.D. dissertation, ETH Zürich, 2015

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