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Optimal design of a medium voltage high frequency transformer with a high isolation voltage (115kV)

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For the new linear collider at the European spallation source (ESS) in Lund, 2.88MW long pulse modulators with pulsed output voltages of 115kV and pulse lengths in the range of milliseconds are required.
For generating many pulses, a long pulse modulator based on a modular series parallel resonant converter (SPRC) topology [1] has been developed. This converter is operated at high switching frequencies (100kHz) to minimize the dimensions of the reactive components and the transformer. To achieve the required output voltage of 115kV, 8 SPRC modules each with an output of 14.4kV are connected in series [2]. Due to the series connection of the secondary windings, the insulation of the oil isolated transformer has to withstand the full pulse voltage of 115kV.
In this paper a design procedure of the medium voltage high frequency transformer using Litz wire is presented. A comprehensive insulation design method based on an electrical field conform design is explained in detail and verified by partial discharge measurements on a prototype system. Additionally, all design models, including a generalized magnetic model for the leakage and the loss calculations as well as an electrical model for the parasitic capacitance estimation for the transformer are derived and proven by measurements.

[1] G. Ivensky, et al., "An RC load model of parallel and series-parallel resonant DC-DC converters with capacitive output filter," IEEE Trans. Power Electron., vol.14, no.3, pp.515-521, May 1999.

[2] M. Jaritz, et al., "Control of a modular series parallel resonant converter system for a solid state 2.88 MW/115-kV long pulse modulator," IEEE Europ. Conf. Power Electron. Appl., 2015.

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