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HV Pulse transformer generalized equivalent circuit identification based on detailed mechanical structure

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The dynamic behavior of High Voltage pulse transformers used in klystron amplifiers cannot be accurately represented with a standard low order lumped equivalent circuit because the distributed parasitic capacitances and leakage inductances are highly dependent of the detailed mechanical structure. A methodology based on generalized high order equivalent circuits identified from 2D and 3D FEA simulations of the detailed transformer structure is presented.
With this methodology, it is possible to derive from the detailed structure and dimensions of an existing transformer an accurate equivalent circuit model that can be used to design the power stage and control system of high performance modulators or to diagnose transient internal winding overvoltages. The method can also be used in an optimal design process of pulse transformers to be used in modulators with tight specifications in terms of output pulse overshoot, rise and settling time.
Generalized high order equivalent circuits of an existing transformer can be identified by splitting the main windings in an arbitrary number n of elementary windings. Each elementary winding is considered as a lumped element with its own capacitance and capacitive influence coefficients with the other elements, and with its own inductance and magnetic couplings with the other elements. Skin and proximity effects in the conductors are also represented by subcircuits with additional mutual inductances and resistances. The generalized equivalent circuit order n can be chosen according to the transformer size and the operational frequency range. The minimal elementary winding is a single coil turn. The elementary capacitance, inductance and coupling factors are derived from specific identification techniques based on 2D or 3D FEA simulations of the detailed mechanical structure.
The identification methodology has been validated on two transformers with a rated output voltage of 9.8kV and 180KV respectively that have been designed and tested at CERN.

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