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The Design of Magnetically Insulated Transmission Lines

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Historically, the design of magnetically insulated vacuum transmission lines (MITLs) was based on successful prior MITL designs, experience & intuition, and simple theory. E&M Particle-in-Cell (PIC) codes were often used more to validate a MITL design than as a primary, iterative design tool. We have used the Screamer circuit code to optimize MITL design based on the assumptions that a constant impedance MITL was desired and that abrupt changes to MITL impedance are to be avoided. We show that the optimum design of an MITL depends strongly on the electrical parameters of the driver and the details of the load. In the case of short circuit (z-pinch) loads, the ideal MITL profiles deviate from an ideal, constant geometric impedance. The presence of inductances inside a transmission line cause the actual impedance of a MITL to be lower than the geometric impedance. This can be a large effect at radii of 15-2 cm and huge effect at smaller radii. Finally, the impedance of a MITL is impacted by vacuum electron flow. We have adopted Mendel's Z-Flow model to obtain an estimate of the "Flow Impedance" of a vacuum transmission line at all locations in the line. We present MITL designs that include details of the load parameters and the effect of vacuum electron flow. Nearly constant-impedance MITLs are designed for drivers with voltages 1-1.5 MV and total currents of ˜ 7.5-10 MA.

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