Design of an AC Transformer in the MHz Range

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Abstract

Due to the Paschen law the ignition voltage for plasma increases proportionally to electrode gap and pressure between electrodes. Atmospheric plasmas operating in the MHz range, being of great interest for surface treatment, require therefore high voltage power supplies, even though in this frequency range, the breakdown voltage and the power needed to sustain the plasma are generally lower than in the kHz range [1]. Our approach in this work is to increase the needed voltage using a transformer.

Transformer design in this frequency range is more challenging than in the kHz range, because not only all electronic components influence the resonance frequency and because parasitic capacities and inductances become more important, but as well the relative permeability of the core causes severe power losses. In this work, we used the AC/DC physics interface of COMSOL Multiphysics® to simulate full electric connections and the coil arrangement of the transformer in order to optimize the gain of voltage and current at the desired frequency of 13.56 MHz. We are particularly interested in the power transmission between the two windings.

The simulations have determined geometric parameters of the primary and secondary windings, relative permeability and geometry of the core to maximise the power transmission. Based on the simulation results, real transformers have been built and characterized, and the measurements compared to the simulation. The shift of resonance once the plasma is ignited has been computed and compared with experiment.

[1] Kunhardt E E, 2000, IEEE Trans. Plasma Sci., 28, 189-200

Figures used in the abstract

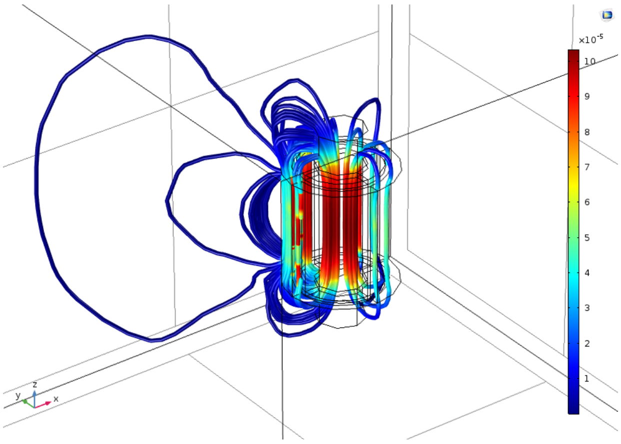

Figure 1: Magnetic flux density in the transformer at 6 MHz.