Impedance Analysis of a Pot Core Inductor

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Introduction: In this work we present a methodology to extract electromagnetic parameters, such as the inductance (L), the equivalent series resistance (Rs), the equivalent parallel resistance (Rp) and the quality factor (Q) of a pot core inductor which thanks its shape forces the magnetic field in a single direction. Obviously this methodology can be applied to several applications

Figure 1. 3D model

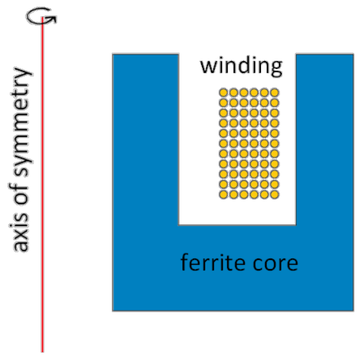

Figure 2. 2D-axisymmetric COMSOL model

Computational Methods: The simulations have been made in a frequency domain with the ACDC module and the Magnetic Field Interface.

$$\begin{cases}(j\omega\sigma - \omega^2\epsilon)A + \nabla \times \mathrm{H} = \mathrm{J_e} \\ B = \nabla \times \mathrm{A}\end{cases}$$

while at the winding:

$$\begin{cases}J_e = \sigma \dfrac{V_{Coil}}{L} e_{Coil} \\ I_{Coil} = \displaystyle\int J \cdot e_{Coil}\end{cases}$$

The appropriate settings for mesh are fundamental for a correct analysis because a single simulation model should include various physical effects, like the magnetic coupling effect between coils, the skin effect in a single wire. Therefore, two types of mesh have been used: a boundary layer and a free triangular as shown in figure 3.

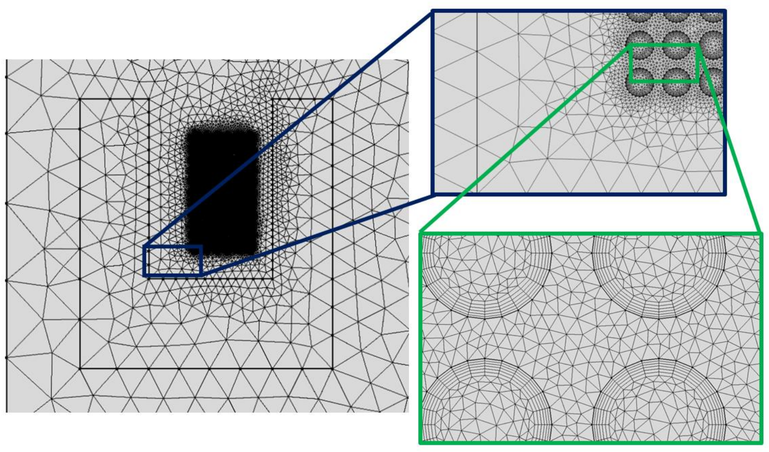

Figure 3. Mesh of the whole structure

Results: An inductor, as first approximation, could be modeled as a series equivalent circuit (A) or a parallel one (B) as follows:

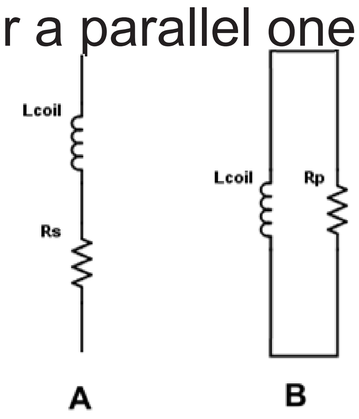

Figure 4. Two topologies of a inductor circuit model

the simulation results are then compared with the measurements:

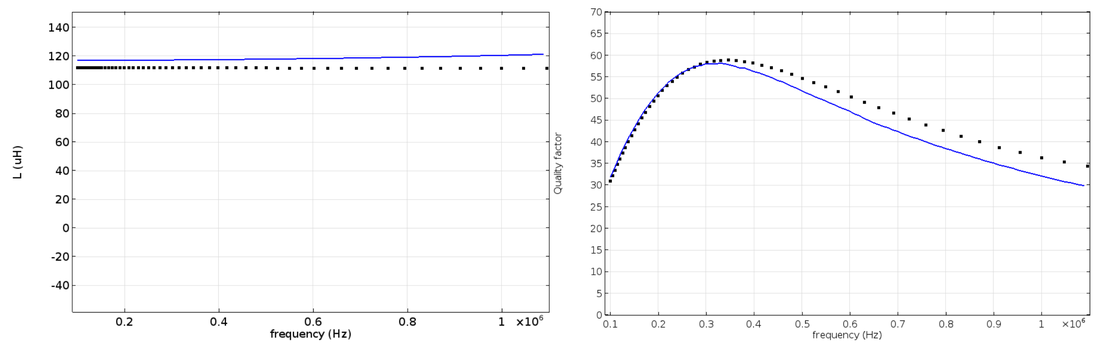

Figure 5. Inductance, quality factor, series resistance, parallel resistance; dotted line represents the simulation points, while blue line the measurements

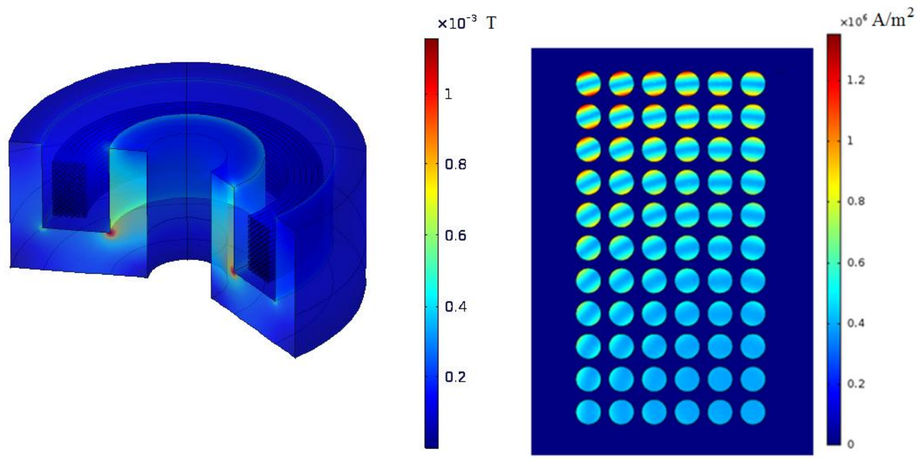

Figure 6. Magnetic flux density of the system and current density of the winding

Conclusions: The obtained results confirm the advantage of the pot core inductor: the figure 6 shows the confinement of the magnetic field and the current density. Moreover, the electromagnetic parameter are in good agreements with the measurements.

References:

1. "ACDC Module Users Guide", COMSOL, www.comsol.com.
2. "Epcos Data book 2013, Ferrites and accessories", Epcos, www.epcos.com

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