Numerical models of the prototype transformer for inductive contactless energy transfer system

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Abstract **This paper describes results of simulation of a transformer used in prototype of energy supply system. The finite element model with use of Argos2D and Comsol Multiphisics software was constructed. Simulation provides an easy way of estimation of the basic transformer parameters, some which can be hard to measure in reality.**

Keywords **FEM, transformer, PRT, Agros2D, Comsol.**

I. The transformer

In this paper we present results of simulation of specific transformer used in a prototype of energy supply system applied in personal rapid transit (PRT) vehicle. The transformer is an integral part of inductive contactless energy transfer system constructed by a group from the Electrical Drive Division at the Faculty of Electrical Engineering, Warsaw University of Technology as a part of the "Eco-mobility" project.

The transformer E-shaped core consists of three equally spaced columns made of 3c90 Ferroxcube material, with secondary winding wounded up around the central column of the core. The primary winding is constructed in a form of a loop.

The unusual shape of transformer raises up some difficulties in measurement of mutual and leakage inductances of the device which are required in circuital description of the system.

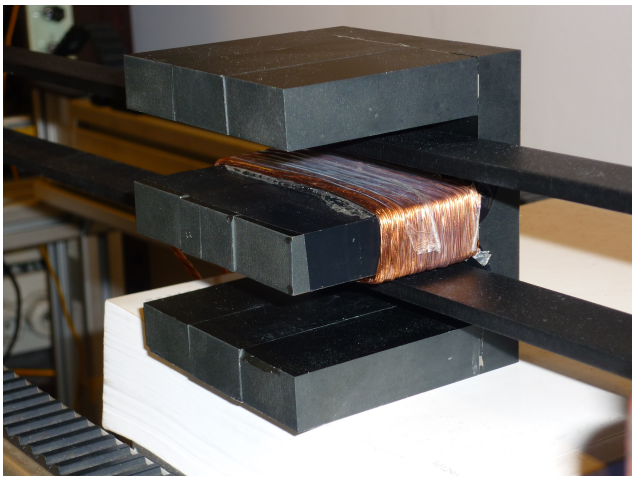

Fig. 1. The transformer prototype

II. Simulation results

Two-dimensional models of transformer were created independently in two programs: Comsol Multiphisics and Argos2D. Based on the 2D models the self-inductance of primary winding, mutual inductance and coupling coefficient were computed.

Computation of self-inductance was performed in two different ways: based on the expression for energy contained in the primary winding and directly, with the use of magnetic flux.

Mutual inductance was computed as the relation of the magnetic flux produced by the primary winding passing through the secondary winding and the current causing the flux.

Various lengths of transformer columns, displacements of winding or variations in material permeability were tested in the simulations to find the best parameters of the prototype. Table I presents computed values of the basic transformer parameters for two different lengths of its core. Computed values of parameters were close to the ones measured in the real system.

TABLE I
Basic transformer parameters
for two different length of its core

Core length [m]	μ	L[H]	M[H]	k
0.089	2000	5.773E-007	5.657E-006	0.448
0.109	2000	7.579E-007	7.454E-006	0.518

III. Conclusion

Presented model of transformer allow us to compute its basic parameters with high precision. Furthermore, it helps to find the optimal dimensions of the transformer core before building the prototype. The three-dimensional model constructed in Comsol Multiphisics system on the basis of the experiments with 2D models is aimed at evaluation of the endings effects at the primary winding (rails) connections. It will be described in the full paper.

IV. Acknowledgements

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