



HAL
open science

Simulations of Transcutaneous Energy Transmitters by using Homogenization Method

Daniela Wolter Ferreira, Ruth V. Sabariego, Luiz Lebensztajn, Laurent
Krähenbühl, Florent Morel, Christian Vollaire

► **To cite this version:**

Daniela Wolter Ferreira, Ruth V. Sabariego, Luiz Lebensztajn, Laurent Krähenbühl, Florent Morel, et al.. Simulations of Transcutaneous Energy Transmitters by using Homogenization Method. 9th EMF, Apr 2013, Bruges, Belgium. pp.#128. hal-00799739

HAL Id: hal-00799739

<https://hal.science/hal-00799739>

Submitted on 12 Mar 2013

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Simulations of Transcutaneous Energy Transmitters by using Homogenization Method

Daniela W. Ferreira¹, Ruth V. Sabariego², Luiz Lebensztajn¹, Laurent Krähenbühl³, Florent Morel³, Christian Vollaire³

¹ Departamento de Engenharia de Energia e Automação Elétricas, Escola Politécnica da Universidade de São Paulo, São Paulo, Brasil.

E-mail: daniela.wolter@usp.br

² Department of Electrical Engineering and Computer Science, University of Liège, Liège, Belgium.

³ Université de Lyon, Laboratoire Ampère (CNRS UMR5005), École Centrale de Lyon, France.

Transcutaneous Energy Transmitters (TET) are wireless devices to transfer energy from outside the body to inside the body. They use inductive coupling between a primary coil external to the body and a secondary coil underneath the skin, similar to a coreless transformer (T. D. Dissanavake, A. P. Hu, S. Malpas, L. Bennet, A. Taberner, L. Booth, and D. Budgett “Experimental Study of a TET System for Implantable Biomedical Devices”, in *IEEE Transactions on Biomedical Circuits and Systems*, vol. 3, no. 6, 2009). Usually, a TET comprises a pair of single layer pancake coils, which are difficult to align. The effect of a possible misalignment has to be considered during the early design stages by e.g. Finite element (FE) simulations. A computationally expensive 3D FE model is required though, especially at high frequencies when accurately accounting for eddy current effects implies considering solid massive conductors. Indeed, taking into account that the TET may consider a wide frequency range with different wire gauge radii, the skin and proximity effects cannot be ignored. Thus, the use of the stranded model is not accurate enough in this case. Several works use the stranded model ignoring these effects and estimating the Joule losses a posteriori.

However, the eddy current effects may strongly alter the TET performance and their direct inclusion in the FE simulations is mandatory. Dedicated homogenization methods thus prove essential. In the frequency domain, they usually amount to the use of complex frequency-dependent reluctivity and resistance values, the expression of which is obtained analytically, or using an elementary FE model. Several authors have dealt with these methods in the frequency domain (J. Gyselinck, and P. Dular. “Frequency-domain homogenization of bundles of wires in 2D magneto dynamic FE calculations” in *IEEE Transactions On Magnetism*, vol. 41, pp. 1416-1419, 2005) and the time domain (R. V. Sabariego, P. Dular, and J. Gyselinck. “Time-Domain Homogenization of Windings in 3-D Finite Element Models” in *IEEE Transactions On Magnetism*, vol. 44, pp. 1302-1305, 2008), to study a multi-turn typical winding inductor, what has homogeneous geometry. Here, a homogenization method is applied to study the single layer coils from the TET with a 3D FE model in the frequency domain. Results will be compared with both the stranded approach and experimental measurements, showing that the homogenization method is very reliable even for single layer pancake coils, where the geometry is not so homogeneous.