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# Identification of main factors impacting human exposure in inductive power transfer systems

Paul Lagouanelle<sup>1</sup>, Fabio Freschi<sup>2</sup> and Lionel Pichon<sup>3</sup>

**Key words:** Inductive power transfer, EMC, Metamodeling

## 1. Introduction and context

In recent years, inductive power transfer (IPT) systems have been widely developed in several fields such as biomedical engineering, consumer electronics and automotive industry.

With such increasing use, the human exposure to the radiated electromagnetic fields from these systems has to be deeply investigated and measured [Cirimele(2018)]. The properties of shields and materials used in such systems are very dependent on many parameters (thickness, number of layers, electromagnetic properties, etc.) and these parameters are corrupted by many uncertainties (measurements errors, approximations) that may have a significant impact on the shielding effect and/or the global efficiency.

For such uncertainty propagation studies, statistical methods based on Monte Carlo simulations may provide reliable results. With this approach, a large set of inputs are considered and many evaluations of a model response are needed. This leads to a heavy computational cost in case of complex system configurations. To avoid the computational burden and deal with a large variability of data, it can be very useful to build adequate meta-models (or surrogate models) [Bilicz(2016)] [Knaisch(2016)][Marelli(2014)].

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## 2. Methodology and results

In order to manage the variability of parameters involved in the assessment of level exposure due to inductive power transfer systems for electric vehicles, the use of surrogate models based on Kriging and Polynomial chaos expansions are presented and applied to simplified but realistic inductive power transfer configurations.

The first case is the power system developed in Politecnico di Torino for dynamic applications [Lagouanelle(2019)]. The second case, studied in INRiM, addresses the exposure related to a system located under a light vehicle [Lagouanelle(2021)]. Meta-models are built from 3D computational results. A sensitivity analysis using Sobol's indices allows to identify the more impacting geometrical or physical parameters involved in the configuration. The study has been performed in the framework of the European project MICEV (Metrology for Inductive Charging of Electric Vehicles).

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## References

1. S. Bilicz, S. Gyimóthy, J. Pávó, P. Horváth, K. Marák, Uncertainty quantification of wireless power transfer systems, IEEE Wireless Power Transfer Conference (WPTC), Aveiro, Portugal 5-6 May 2016.
2. V. Cirimele, M. Diana, F. Freschi, M. Mitolo, "Inductive power transfer for automotive applications: state-of-the-art and future trends, IEEE Trans. on Industry Applications, Vol. 54, n°5, pp 4069-, 2018.
3. K. Knaisch, P. Gratzfeld, Gaussian process surrogate model for the design of circular, planar coils used in inductive power transfer for electric vehicles, IET Power Electron., Vol. 9, Iss. 15, pp. 2786-2794, 2016.
4. P. Lagouanelle, V-L. Krauth, L. Pichon, Uncertainty Quantification in the Assessment of Human Exposure near Wireless Power Transfer Systems in Automotive Applications, Automotive 2019, Torino, July 2-4th, 2019.
5. Paul Lagouanelle, Oriano Bottauscio, Lionel Pichon, Mauro Zucca. Impact of parameters variability on the level of human exposure due to inductive power transfer. IEEE Transactions on Magnetics, 2021.
6. S. Marelli, and B. Sudret, UQLab: A framework for uncertainty quantification in Matlab, Proc. 2nd Int. Conf. on Vulnerability, Risk Analysis and Management (ICVRAM2014), Liverpool, United Kingdom, 2014, 2554-2563.