

Error analysis for near-field EMC problems based on multipolar expansion approach

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Abstract—The characterization of near-field couplings becomes an extremely important activity to optimize the best nominal performance of any electronic device in the presence of others. In order to handle the electromagnetic compatibility (EMC) problems at the initial design phase, a predictive method based on multipolar expansion in spherical harmonics has been developed. A new automatic measurement system has also been designed which allows the measurements of the magnetic field all around the device. In this paper, the impacts of the measurement uncertainties and the disturbances caused by the power wires are studied.

Index Terms—Electromagnetic Compatibility, spherical harmonic, power electronics devices, quasi-static fields .

I. INTRODUCTION

Characterization of electromagnetic interference (EMI) between two power electronic systems is an important issue in electromagnetic compatibility (EMC). However, EMC problems are currently treated after the production of a prototype, which causes additional costs and significant delays if the needed standards are not reached. In order to consider the compliance to EMC standards from the very beginning of the design phase, a method has been developed to predict near-field coupling between complex components [1]. This predictive method is based on the multipolar expansion of the field close to the Device Under Test (DUT) in spherical harmonics. With the measurements of magnetic flux all around, this DUT can then be represented by an equivalent punctual source in multipolar expansion, which allows calculating the near-field coupling with other components.

The multipolar expansion in spherical harmonics allows decomposing any near field into an infinite sum of known standardized terms (dipole, quadrupole, octupole, etc.). For the near field studies (<1m in the 20 kHz-20 MHz range), the quasi-static approximation is suitable. Once the harmonic coefficients of two systems are identified, we can determine the coupling between them through the calculation of the mutual inductance [2]. It should be noted that the accuracy for the calculation of the mutual inductance is directly related to the choice of the maximum degree (N_{max}) used in the expansion.

II. PROPAGATION OF UNCERTAINTY

In the previous work [1], a measurement bench has been only developed to determine the zero-order components of the first four degrees of the multipolar expansion ($N_{max} = 4$),

which is exclusively limited to axially symmetric sources.

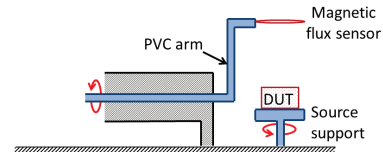


Fig. 1: schematic diagram of the measurement bench

A new automated measurement bench has been designed at Laboratoire Ampère. This bench allows two rotational movements via: a PVC arm in the vertical direction and a source support in the horizontal direction as shown in Fig 1. A set of measurements can be done with the measuring positions uniformly distributed on a spherical surface with the DUT in the center. The radiation source could then be identified in multipolar expansion with both zero- and non-zero-order components. Thus, the dimension of the magnetic flux sensor and the length of the measuring arm can both be changed according to the DUT size and the required accuracy. It should be noted that the final measurement results could be deviated by errors of different types [3]. These errors consist of electromagnetic noise during the measurements, the uncertainties of the sensor positions, disturbances due to the power wires, etc. An error analysis must be done in order to take into account all these uncertainties. The purpose of this paper is to study how these uncertainties impact the spherical harmonic components and also the computed mutual inductance. These errors could be quantified in function of the confidence level which could be expressed as an interval ($x \pm \Delta x$). The dynamic performance of the relative errors on the spherical harmonic components and the mutual inductance is the critical criterion for the choice of the measurement positions. Finally, a relation could be established between the accuracy, number of measurements and N_{max} . With this in mind, several theoretical and numerical results which have already been established in the previous work could be verified experimentally such as the optimal choice of the origin and the effects of secondary sources.

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