Progress report

Stochastic methods in Time Domain simulations

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Outline

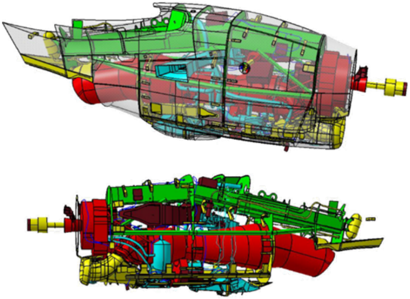
Brief recap

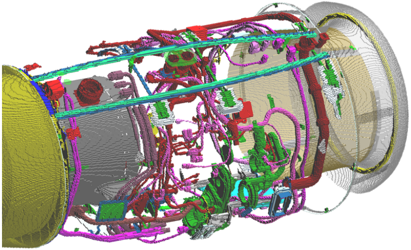
Our team has a time domain simulation tool (SEMBA) currently mainly used for EMC analysis by Airbus and INTA. This tool includes:

- A GUI through **GiD** that allows to the direct use of **CAD data** and has **pre and post-processing capabilities**.
- Several different **Physical models**: materials, thin layers, wires, connectors.
- Several **meshers**: conformal and structured. Capable of generating meshes with billions of cells within seconds.
- A state-of-the-art **FDTD solver**: MPI/OpenMP, improved accuracy with conformal meshing, frequency dependent materials, cable bundles and harnesses, multilayered composites.

Current status

EMC engineers often have a **lack of full knowledge** of: material properties, geometries, wires routing, electric contact, testing conditions... This leads to **uncertainties** in the design.





Development of guidelines

At the moment, the effects of these uncertainties are mostly modeled *by hand*. This relies on the engineer experience to take decisions on which parameters affect more the outcomes.
This approach will be probably necessary anyhow, and **some guidelines will always be needed** to enclose the problem space.

- Guadalupe G. Gutierrez, Daniel Mateos, Miguel R. Cabello, Enrique Pascual-Gil, L. D. Angulo, and Salvador G. Garcia. On the design of aircraft electrical structure networks. *IEEE Transacions on Electromagnetic Compatibility*, 58(2):401 – 408, March 2016
- G. Gutierrez, S. G. Romero, M. Gonzaga, E. Pascual-Gil, L. D. Angulo, and S. G. Garcia. A quantitative study of the geometrical simplification influence on a lightning simulation. *IEEE Transacions on Electromagnetic Compatibility*, 2016. In preparation

Trivial uncertainties

Some of these **uncertainties can be treated trivially assuming linear response**, *e.g.* using transfer functions we already account for uncertainties in the intensity of an EMI.

Uncertainties in geometry

At the moment, commercial software allows parametric geometric sweeps only for basic shapes, or compositions of basic shapes. We know no way of parameterizing complex CADs or wire routings. Therefore, **we know no way of dealing with uncertainties in geometry in a generic way**.

Uncertainties in parameters

Some can be modeled with **changes in the equation parameters**. *e.g.* changes in electric permittivity, changes in resistance of connectors... Stochastic methods aim to solve these situations.

Monte-Carlo method

In the light of this, we are currently doing a bibliographical investigation on different alternatives to model parameters.

Monte-Carlo method

The Monte Carlo (MC) method is the *gold standard* of statistical simulations providing reliable results given a large enough number of simulations. However, the Monte Carlo method is unaffordable for complex 3D problems.

Stochastic FDTD

Stochastic FDTD (S-FDTD)

S-FDTD uses perturbation theory to derive, from Maxwell's equations, a set of equations that accounts for random variables.

- Results are within one order of magnitude compared with the ones obtained by an MC method.
- Doubles memory consumption and CPU time but only needs to run once.

S. M. Smith and C. Furse. Stochastic fdtd for analysis of statistical variation in electromagnetic fields. *IEEE Transactions on Antennas and Propagation*, 60(7):3343–3350, July 2012

Conclusions

Current status

- Uncertainties are currently mostly modeled *by hand*.
- Guidelines will always be needed, reducing the search space.
- We only aim to treat uncertainties in parameters, not geometry.

Ongoing work

- Monte Carlo method is the most reliable approach, but unaffordable.
- S-FDTD can provide reasonably good results with a single run.

Contact

More information available in our webpage:

`www.sembahome.org`

Video tutorials are available in the SEMBA channel in YouTube.