A Simulation Tool for the Stochastic Electromagnetic Field Coupling to a Uniform Transmission Line

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1. Purpose of the Program
Stochastic electromagnetic fields:
- reverberation chambers → ensemble of stirrer positions
- crossmoded cavities → nearby positions or frequencies
Transmission lines:
- one of the most important coupling paths of disturbances
- terminal voltage or current also become stochastical values
- simulation/calculation based on transmission line theory

Simulation Program:
- easy to use, Monte Carlo approach and analytical solutions

2. Technical Background
2.1 Field Model
Plane Wave Integral Representation [1]:
- field is modeled by a superposition of plane waves
- incident directions are equally distributed over the full solid angle
- no specific phase or polarization angle is to be favored

Usefulness of a stochastic approach:
- if the significance of a deterministic solution is small
- parameters are unknown, but could have a rather large influence on the actual result, e.g.
  - exact direction of incidence of the external field
  - exact position and orientation of the line are unknown

Preconditions:
- only valid for an ideal reverberation chamber
- inside the working volume far away from the walls
- high frequency and sufficient mode density
- efficient mode stirrer → independent field distributions
- steady state → field distribution and spatial correlation

Chamber constant [1]:
- from the quality factor ($Q$), the input power ($P$), the angular frequency ($\omega$), the permittivity of the medium, and the chamber volume ($V$)

Simplifications of the transmission line theory:
- line is straight, uniform and lossless
- current is concentrated on the wire axis
- cross section dimensions < wavelength
- differential mode only, no antenna mode, no radiation
- field along the line is transversal electromagnetic

Agrawal formulation of the transmission line equations:
- solution non-uniform distribution of the polar angle
- advantages: only tangential E-field needed, numerically efficient
- disadvantage: only the scattered voltage is calculated

Solution for the current along the line [4]:
- similar solution for the scattered and total voltage

3. Graphical User Interface

4. Summary and Outlook
Summary:
- statistical simulation tool with GUI for field-to-cable coupling
- allows comparison of numerical and analytical results
- developed in MATLAB, execution only needs MATLAB Compiler Runtime (MCR)
- source code is available from the author
- similar program is available for the field simulation only

Outlook:
- multi-lingual support
- add more languages
- rewrite in Octave/C as cross-platform support
- include calculation schemes from other authors [5, 7]

References

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