Combining The Finite Element Method (FEM) and The Random Coupling Model (RCM) for Quasi 2D Cavities

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Abstract—The Random Coupling Model (RCM) provides a statistical model of calculating the electromagnetic (EM) coupling in a complex enclosure. The Finite Element Method (FEM) is a widely used computational method to solve EM problems for complicated structures. In this work, a combination of the RCM with the FEM is shown that requires meshing only for a small region of a quasi 2D cavity while the rest can be predicted by the RCM.

Keywords- Random Coupling Model; Finite Element Method; Quasi 2D Cavity; Statistical Electromagnetics

I. INTRODUCTION

The Random Coupling Model (RCM) is a method for making statistical predictions of induced voltages and currents for objects and components contained in complicated (ray-chaotic) over-moded enclosures and subjected to RF fields. On the other hand, the Finite Element Method (FEM) is a widely used computational method that solves the wave equations numerically. We show a combination of the two methods where we consider an aperture backed by a wave chaotic cavity. The FEM gridding is usually required for the entire geometry. But in this work, we show that one can grid the region close to the aperture while rest of the cavity can be modeled by the RCM.

II. PROBLEM SETUP

A. *Setup of The Geometry*

We model a quasi 2D cavity with an aperture. This is done in the commercial software HFSS. Perfectly Matched Layers (PMLs) are placed on one side of the aperture, while on the other side the boundary is treated as a port and the fields are represented in modes.

B. *Aim of the Simulation*

We want to determine numerically the power through the aperture. We would like to do this without simulating the entire cavity, only the aperture. The influence of the cavity will be described by the RCM. In particular, the scattering matrix relating the modes on the cavity side of the aperture will be simulated by the RCM.

III. METHODOLGY

A. *Equations*

We excite the cavity side of the aperture with each of the 25 modes and record the far field patterns at the PML. We then use these profiles and the principle of reciprocity to find the current on the port for an incident plane wave from outside the cavity and find the admittance matrix on the aperture side of the port. We then use an RCM matrix to model the other side of the port and determine the fields on the port for various incident waves

$$I_m^{inc}(\mathbf{k}_i) = \sum_{m'} \left(Y^{>}_{mm'} + Y^{<}_{mm'}\right) V_{m'} \qquad (1)$$

Once we have these fields, we can calculate the power seen at the receiving port by

$$P = \frac{1}{2} Re\{V^* Y^{>} V\} \qquad (2)$$

B. *Figures*

Results of Power entering cavity: We solve (2) 10,000 times with different realizations of the port admittance and make a histogram plot. The results are displayed in Fig. 1.

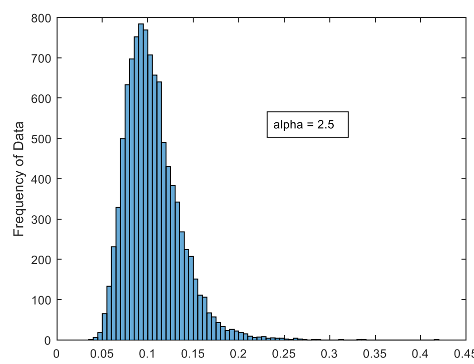

Figure 1. Histogram plot for power coupling to the aperture.

REFERENCES

[1] Hemmady et al., "Statistical Prediction and Measurement of Induced Voltages on Components Within Complicated Enclosures: A Wave-Chaotic Approach," IEEE Trans. Electromag. Compat. **54**, 758-771 (2012).

[2] Gradoni et al., **"**Impedance and power fluctuations in linear chains of coupled wave chaotic cavities**,"** Phys. Rev. E **86**, 046204 (2012)