Increasing Peak-Power Field Generation Efficiency in Reverberation Chambers

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***Abstract*— In the present work we compare the efficiency of generating high-intensity fields inside a reverberating chamber in the case where the test volume is driven by continuous waves and when excited by a time-reversed signal. Experimental results are compared to an asymptotic model showing the importance of frequency bandwidth and losses within the chamber.**

Keywords-efficiency; electromagnetic compatibility test; peak-field; reverberation chamber; time-reversal.

I. INTRODUCTION

A reverberating chamber (RC) usually consists of a rectangular test chamber with metal walls and a stirrer that allows one to smooth out the sharp nulls of the field. During immunity tests, the average response of the object to the field is found by integrating the response over multiple stirrer positions. The equipment under test (EUT) is thus exposed to high field levels. For frequencies where the chamber is highly overmoded, the test facility is considered to be a perfectly diffuse system. The electromagnetic environment is then characterized as being isotropic, randomly polarized and uniform. The field arriving at any point in the volume can be described as an infinite sum of plane waves propagating in all directions of the volume with the same probability [1]. In such an environment a statistical approach is more suitable given the field description complexity.

When the RC is driven by a continuous-wave (CW) harmonic signal, only a fraction of the total energy stored within the chamber can be used as aggression on the EUT. When carrying out certain electromagnetic compatibility tests, it would be more useful to be able to choose the incidence angle and to concentrate the field on the EUT. This scenario can be achieved by using time reversal (TR) techniques [2]. In such a case, the RC can be used as a high-intensity field generator.

Based on prior work in the case of energy efficiency [3], we propose an asymptotic model capable of predicting the average improvement brought by time reversal techniques on peak-power field generation. Experimental results have allowed us to check the validity of the model.

II. THEORETICAL MODEL

In a similar way than in [3] we define the peak power generation efficiency as the square-root of the ratio between maximum field according to one direction $\max_t |e_n(t)|^2$ and the peak power injected in the RC, P^{peak} such that,

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$$\eta^P = \sqrt{\frac{\max_t |e_n(t)|^2}{P^{peak}}} = \frac{\max_t |e_n(t)|}{A^{peak}} \quad (1)$$

In order to compare the case of standard use of RC's with the case when using time-reversal techniques we derived a simple asymptotical model of the ratio between efficiencies based on the works in [3]:

$$G^P_{ave} = \frac{\langle \eta^P_{TR} \rangle}{\langle \eta^P_{CW} \rangle} = \sqrt{\frac{1}{3} G^\varepsilon_{ave}} \le \sqrt{\frac{B_t \overline{Q}}{6\pi f_c}} \quad (2)$$

where $\langle\ \rangle$ is the ensemble averaged value and G^ε_{ave} the asymptotic model developed in [3] with B_t the bandwidth, f_c the central frequency and $\overline{Q}$ the average quality factor.

III. EXPERIMENTAL RESULTS

Experimental data were obtained in a 45 m^3 reverberation chamber. A total of 50 stirrer states and 16 spatial positions for two field polarizations were considered. Measurements were performed for 3 different frequencies. Figure 1 shows the variation of the ratio between model and measurements with respect to the bandwidth. We obtain very good agreement between model and experiments especially when the bandwidth is large.

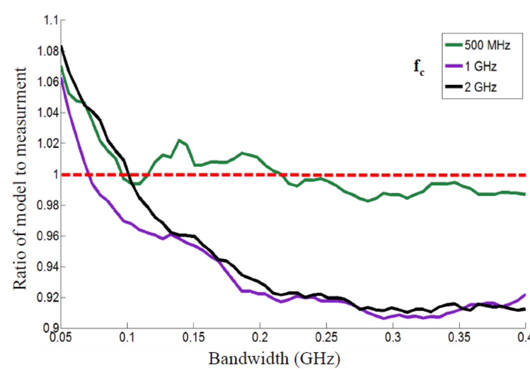

Figure 1. Ratio of model to measurement according to bandwidth for the average efficiency improvement using time reversal.

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