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Shielding Effectiveness Measurement in a Multiple Monopole Source Stirred Reverberation Chamber

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Abstract

This paper reports the measurement of the shielding effectiveness of a metallic enclosure. The experimental environment is a reverberation chamber where the multiple monopole source stirring technique is implemented. The results are compared to the measurements in the same environment, by using a traditional mechanical stirring technique and to the anechoic scenario using numerical simulations.

1 Introduction

Shielding effectiveness (SE) was measured using Reverberation Chambers (RCs) since 1988 [1] [2]. In this measurement environment, the electromagnetic field inside a subvolume, called working volume, is statistically uniform, isotropic and with a random polarization, so the SE measurement in RCs has the advantage over other techniques in that the reverberation chamber exposes the material to a more realistic environment [3].
In fact, according to Hill [4], the plane wave representation of the electromagnetic field inside a RC involves the SE measurement as if the field came from random incident directions and with arbitrary phase. This leads to a more complete measurement with respect to an anechoic scenario where only a finite number of incident directions of the electromagnetic waves is considered. Moreover, the power supply is usually placed inside the metallic chassis of the workstation, and the RC represents better this scenario than an anechoic environment.
For all these reasons, the SE measurement in RCs has been of research activities [5] – [7].
There are many ways to achieve the stirring action in a RC [8] but they can be classified in two families: in the first one the stirring technique is based on the variations of the field boundary conditions; this actions can be realized using one or more rotating metallic scatters [9], moving [10] or vibrating [11] the RC's walls. The second family of actions is based on the variations of the source amplitude, phase or position to achieve to so called source stirring action [12] [13].
The scope of paper is to perform SE measurements in a RC where a multiple monopole source stirring (MMSS) action is implemented. This technique [13] [14] is based on an array of monopole antennas placed onto the RC's walls. One monopole is fed at a time and varying the position of the transmitting antenna also the configuration of the electromagnetic field inside the cavity varies so achieving the stirring action. For sake of comparison, the SE measurements were repeated using the same RC, but using the more traditional mechanical stirring action.
Numerical simulations in anechoic (AE) scenario were performed to have a comparison between the RC and AE environments.

2 Equipment Under Test

The equipment under test (EUT) is the metallic enclosure of a power supply for a workstation having rectangular shape (dimensions 142 mm × 85 mm × 149 mm). A 40 mm monopole antenna is placed inside the enclosure to measure the induced voltage.
The enclosure has some apertures (Fig. 1) for cooling purposes through which the electromagnetic field penetrates inside the EUT, so reducing the SE of the enclosure itself.

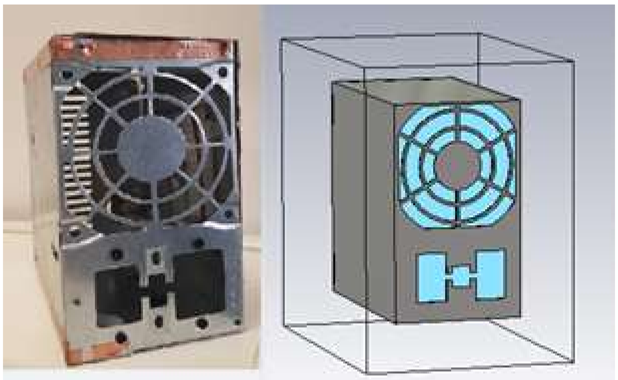

Figure 1. The Equipment Under Test (left) and its numerical model (right)

3 Measurement Setup

The RC used of SE measurements is a rectangular cavity made by galvanized steel (dimensions 800 mm × 900 mm ×1000 mm), that can be used with two stirring techniques, as described in [15], see figure 2:

- A monopole antenna can be inserted into one of the 100 holes (5 mm of diameter): changing the position of the transmitting antenna the MMSS actions is achieved.

- A Z folded paddle can be inserted and manually rotated to have the mechanical stirring action. The stirrer is moved by 3.6° each step to get 100 different realizations. The transmitting antenna is the same monopole antenna used for MMSS scenario, but it is placed in a fixed position, close to the stirrer.

No optimization was used neither for the position of the monopoles [16] nor for the shape of the stirrer.

Figure 2. Measurement setup.

In both scenarios, the transmitting monopole is connected to the port 1 of a Vector Network Analyzer (VNA) that feeds it with a power of 0 dBm. Port 2 is connected to the monopole placed inside the EUT to measure the induced voltage. All the measurements are performed in the frequency range included from 675 MHz (3 times the resonance frequency of the first mode of the RC) and 6 GHz (the highest frequency of the used VNA). In this interval 1601 frequency points are measured.

3 Shielding effectiveness measurements

Shielding effectiveness of the enclosure of the EUT described in the previous section was calculated according

$$SE = 20 \log_{10}\left(\frac{V_{avg}^{(shield)}}{V_{avg}^{(no\ shield)}}\right) \quad (1)$$

where $V_{avg}^{(shield)}$ and $V_{avg}^{(no\ shield)}$ represent the average values of the induced voltage amplitude into the DUT with and without the metallic enclosure respectively.

The choice of using the average values instead of the peak values is due to the fact that, with accordance to other SE definitions in literature [6] [7] we are interested in the shielding effect, averaged on all the electromagnetic field realizations. SE measured values in the two scenarios are reported in Fig. 3

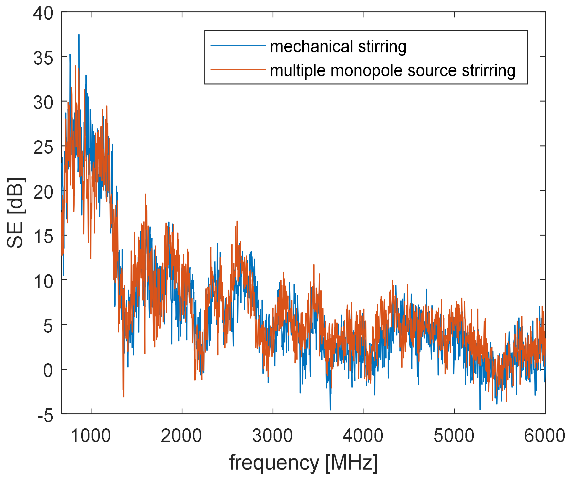

Figure 3. Measured Shielding Effectiveness.

Two considerations emerge from Fig. 3: the first is that the stirring technique does not affect significantly the measurement of the shielding effectiveness. The second is that there are some points where the SE assumes values lower than 0 dB. They represent frequencies where the enclosure resonances enhance the internal electromagnetic field [7]. The choice of the simple definition (1) is aimed at the comparison among different stirring techniques, so no compensation methods are adopted.

4 Numerical Simulation

The goal of this section is to compare the SE evaluated in an anechoic environment with the SE measurements in RC. To predict the SE in an anechoic scenario, a commercial numerical tool [17] was used. The simulated scenario was the following: a plane wave illuminates the EUT placed inside the simulation volume surrounded free space conditions. For each frequency, a set of 12 simulations was performed, uniformly changing the direction of propagation (ϕ) of the plane wave from 0° to 360°. A 40 mm dipole is placed inside the EUT and its orientation is parallel to the electric field of the plane wave, Fig. 4.

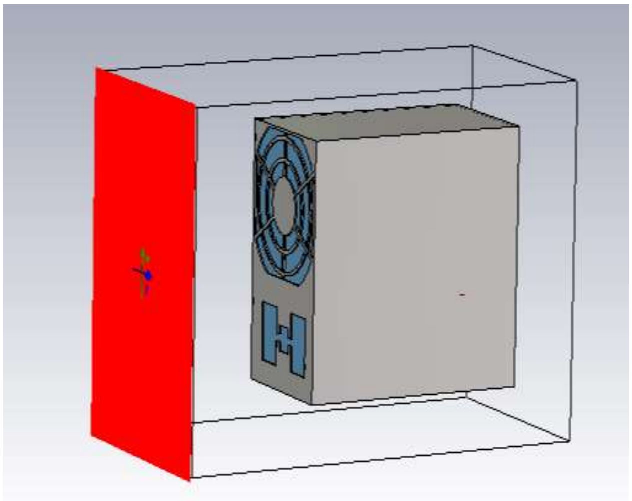

Figure 4. Scenario for numerical simulations: the red dash indicates the sensing monopole position.

Fig. 5 reports the SE obtained by the numerical simulations with different incident angles: we can observe the great SE variation due to the electromagnetic wave direction of arrival, thus confirming the proper use of an RC for this kind of measurements because it, by its natural physical behavior, accounts for this effect.

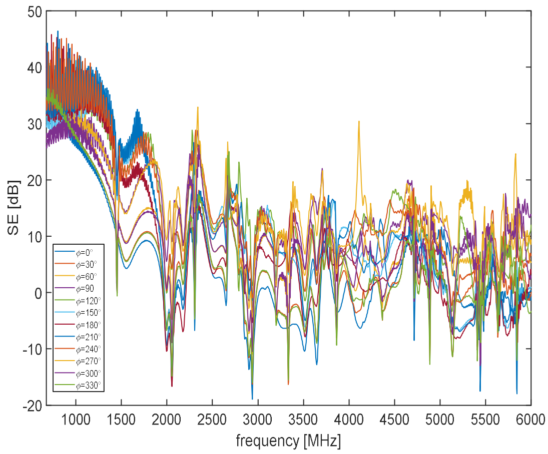

Figure 5. Simulated SE for different incident angles in an anechoic environment.

To have a comparison between RC and AE environment, the values of SE were averaged and compared to the measurements (Fig. 6). The two curves are in agreement, showing that RC is an excellent alternative to the anechoic environment.

5 Conclusions

The paper reports the application of a well assessed technique, the SE measurement in RC, using a novel stirring technique, the MMSS. The results are in good accordance with the ones obtained in the same RC, but using the mechanical stirring, and with the numerical simulations that represent an anechoic scenario.

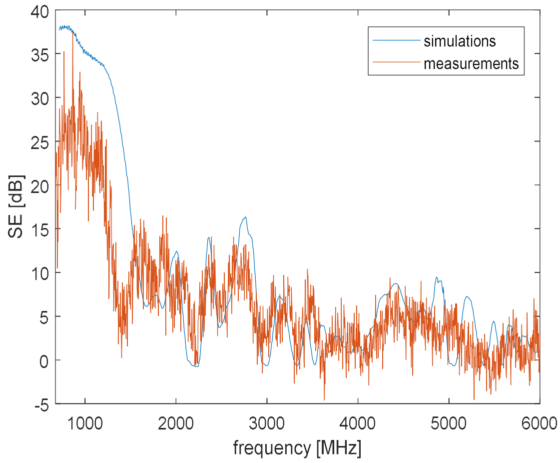

Figure 6. Simulated and measured SE.

6 References

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