ENERGY IN THE HEART OF WAVES
RESOURCES AND ENVIRONMENT:
SMART MANAGEMENT

Measurement of the Radiation Pattern of a Horn Antenna in a Vibrating Intrinsic Reverberation Chamber

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Abstract

In this paper, we present promising results when determining the radiation pattern of an antenna within a fully stirred vibrating intrinsic reverberation chamber (VIRC). The aim is to separate the direct line-of-sight (LOS) path between the antenna under test and the measuring antenna from all other indirect paths within the VIRC. The proposed method uses a simple averaging technique based on multiple S_{21} measurements collected between two antennas for a given angle. The method is successfully tested on a broadband horn antenna at 11 GHz, using a recently installed VIRC at Cisteme.

1 Introduction

Vibration Intrinsic Reverberation Chamber (VIRC), proposed in the early 2000's, have improved in many points electromagnetic compatibility (EMC) testing performed in reververation chambers [1]-[2]. VIRCs are metallized tents changing of shape during testing and are cost-effective and flexible compared to anechoic or reverberation chambers of similar volume.

Three methods have been proposed in the past for antenna radiation pattern measurement in reverberation chambers (which are cheaper than anechoic chambers in reason of the absence of absorbers on the walls) : the K-factor method [3], the Doppler spectrum method [4], and the Time-gating technique [5]. Each method has a few drawbacks such as a long measurement time, a complex setup, and / or a complex post-processing.

In this paper, we are introducing a new method for determining the radiation pattern within a completely stirred VIRC which is therefore elevated of a few centimeters from the floor. This method benefits on the fact that we have tried to move any parts of the canvas from the stirring process.

The determination of the radiation pattern is introduced theoretically in the second section while the third section present encouraging results obtained on a horn antenna at 11 GHz.

2 Theory

The radiation pattern measurements are determined by extracting the LOS signal and discarding all the NLOS paths. To do so, the scattering parameter S_{21} between both antennas must be measured. In a VIRC, as shown in Fig.1, the S_{21} parameter can be decomposed as follows for a given measurement of index i

$$S_{21,\mathrm{i}} = S_{21}^{LOS} + S_{21,\mathrm{i}}^{sti} \qquad (1)$$

where S_{21}^{LOS} correspond to the direct LOS path (which is constant) and S_{21}^{sti} correspond to the sum of the stirred paths that interact with the stirring paddles for this measurement i.

If the VIRC is perfectly well-stirred, the LOS is the only invariant path and so a simple averaging should be sufficient to cancel the unstirred paths, i.e.

$$\langle S_{21} \rangle = S_{21}^{LOS} \qquad (2)$$

3 Validation

For the method validation, the radiation pattern measurement of a horn antenna mounted on a rotating mast has been done inside the VIRC according to the experimental setup shown in Fig. 2. The VIRC is stirred with four fans located outside the VIRC, at a distance of (roughly) 1 meter from each VIRC corner.

S_{21} measurements have been made with a vector network analyzer at 11 GHz. The measurements have been repeated with a step angle of 1° over 360 angles, each for 500 successive sweeps. The radiation pattern is obtained by averaging the S_{21} data over 500 sweeps for each angle of the radiation pattern.

Fig. 3 compares the radiation pattern measurement obtained at 11 GHz inside the VIRC to a reference result obtained in our anechoic chamber where a distance of around 7 meters were used between both antennas. We can see clearly that the main lobe of the radiation pattern is well reproduced, and the dynamic of the measurements is around 20 dB. However, the accuracy is lower for angle larger than ±100 degrees. To improve the results, we need probably to improve the stirring process of the VIRC, especially for the bottom and the top faces of the VIRC. Additionally, we need to check the accuracy of this measurement at a lower frequency, our first results obtained below 5 GHz shows a clear degradation with respect to the results obtained at 11 GHz.

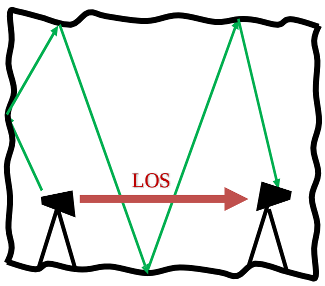

Fig.1. Schematic description showing the LOS path and unstirred paths (in green) in a VIRC during a radiation pattern measurement

Fig.2. Picture of the experimental setup installed in the VIRC of CISTEME

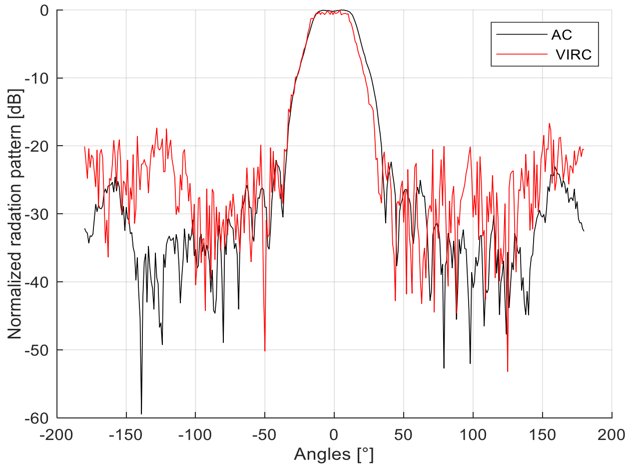

Fig.3. Normalized radiation pattern (in dB) of the horn antenna obtained inside the VIRC (for 500 S_{21} successive acquisitions) and in an anechoic chamber at the frequency of 11 GHz.

4 Conclusion

This article introduces a new method for determining the radiation pattern of an antenna inside a VIRC. The method uses a straightforward experimental setup and post-processing technique that requires only to average the collected data for a given angle. We plan in the near future to enhance the stirring process of the VIRC in order to expand the dynamic range of the measurements and to better understand the factors that seems to limit the technique at lower frequencies.

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