Observation of semi anechoic room influence on high frequency antenna measurements

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Abstract. Radiation patterns of antennas are among their most important characteristics. A popular method to obtain these consists in measurements inside anechoic chambers. However, in common engineering practice, small laboratories are usually equipped with only one shielded chamber. Such chambers are basically semi anechoic, providing a possibility of their modification to a fully anechoic version by placing appropriate absorbers on their reflective floor. Unfortunately, the systematic placement of absorbers on the floor of the chamber and their re-extraction increases the laboratory operating costs as it is time consuming and, moreover, there is a risk of mechanical wear or damage of the absorbers. Therefore, the authors of this paper decided to explore how great the impact of absorbers placed on the floor of the semi anechoic chamber is in case of measurement of radiation patterns of antennas operating at frequencies of 1 GHz and higher. Description of the experiment and its results are provided within the framework of this paper.

1. Introduction
There exist a number of methods for obtaining of antenna radiation patterns. Most of them have been developed in the period of the first radio boom and their exhaustive description can be found in [1] or [2]. The method described in this paper is based on direct measurement inside anechoic chambers, assuming that both, the transmitting and the receiving antenna, are sufficiently distant in order to consider their EM field as a far-field.

1.1. Radiation patterns measurement in anechoic chambers
This method is well described in [2]. According to [1], the antenna range inside an anechoic chamber belongs to free-space range that are designed in such a manner that all the effects of the surroundings are suppressed to acceptable levels. The shielded anechoic chamber seems to be an ideal place for such measurements as it simulates free-space conditions with no interferences penetrating from outside. However, the suppression of the reflections inside the chamber is never ideal, as shown for example by experiments [3], [4]. Therefore, dimensions of such a chamber should meet the condition defined by [1]:

\[ W \geq \frac{R}{2.75} \]  (1)

Where \( R \) is the separation between source and test antennas and \( W \) is the dimension (width and height) of the chamber. In other words, the dimensions of the chamber restrict the maximum possible separation

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of antennas $R$. Another restriction follows that acceptable results can only be obtained in Fraunhofer’s field. This means that the separation between the antennas should comply with the following equation [5], where $D$ is the largest antenna’s dimension and $\lambda$ is the wavelength:

$$R \geq \frac{2D^2}{\lambda} \land D >> \lambda$$  \hspace{1cm} (2)

1.2. Difference between anechoic and semi anechoic chambers for EMC

Widely spread semi anechoic chambers, such as Frankonia SAC 3+, are designed to simulate Open Area Test Site conditions [7]. That means that the receiving antenna is excited not only by a direct wave, but also by the wave reflected from the ground as depicted in Figure 1 [7]. This configuration is required for most tests from the field of electromagnetic compatibility.

![Figure 1. Open Area Test Site conditions of measurement [11]](image)

The semi anechoic chamber can be transformed into a fully anechoic one once its conductive ground plane is covered by appropriate absorbers. An exhaustive description of related issues is to be found in [1-4]. Usually, pyramidal absorbers made of a conductive film applied on an electrically neutral substrate are used. Even among quite complex and expensive laboratory instrumentation, the absorbers based on thin polystyrene blocks can be found. Caution is required when handling of such equipment.

1.3. Horn antennas

For frequencies as high as 1 GHz or higher, double-ridged horn antennas are among widely spread transducer types. A typical construction of such antenna is depicted in Figure 2. Directivity and gain of such antennas is determined by their dimensions $L$, $a_1$, $b_1$ as well as the minimum separation $R$ required for measurement of their radiation patterns. Description of horn antennas principle of operation can be found in [6] or [8] or [9]. Radiation patterns of such antennas consist of one main lobe the width of which is usually in tens of degrees, depending on the antenna’s geometry and transmitted frequency, and several side lobes that are suppressed at least by 10 dB or more.

2. Experiment description

The experiment was performed inside a semi anechoic chamber Frankonia SAC 3+ that is operated at the Tomas Bata University in Zlín. The authors’ aim was to explore how much the reflective ground floor affects measurement of radiation patterns of a horn antenna Rohde & Schwarz HF 906.

2.1. Experiment conditions

This measurement was processed in two planes, horizontal and vertical one. According to the performance of the antennas and the restrictions arising from (1) and (2), the following three frequencies were applied: 1.0, 2.5 and 5.0 GHz. Both the transmitting and the receiving antenna were of HF 906 type and placed 1.0 m above the chamber’s floor. While the receiving antenna was mounted on a fixed tripod, the tripod of the transmitting antenna was placed on a revolving table driven by the measuring system. The spatial separation between antennas was 3.0 m. The transmitting antenna was driven by a sinusoidal signal the power of which was as high as 10 dBm. The arrangement of the measurement stage was in accordance with Figure 3. The process was controlled by Rohde & Schwarz EMC 32 software. The measured values were compared to a simulation that is available at [10].
2.2. Experiment process
Both antennas were set to horizontal polarization. No absorbers were placed between them. The transmitting antenna was rotated by 360° and for each of the applied frequencies its azimuth chart was recorded. Both antennas were then set to vertical polarization and the process was repeated. In this step the elevation chart was recorded.
In the next step, 135 pyramidal absorbers were placed on the floor between the antennas and the measurement process was repeated. The obtained data were imported to MS Excel in order to create comparative radiation patterns in Cartesian coordinates. Moreover, data obtained by simulation (see [10]) were added.

3. Results
The results obtained by the above described experiment are depicted in Figure 4. The radiation patterns are expressed in Cartesian coordinates within the range from – 180° to + 180°. The simulation results were obtained only for the range from -90° to +90° and are depicted with a dashed line.

3.1. Discussion
At the frequency of 1 GHz a certain consistency between the measured and simulated results can be observed, especially in the region of the main lobe. On the other hand, the side lobes measured with no absorbers on the floor are much greater compared to the measurement with the reflections attenuated by the absorbers (Figure 4, bottom left). Considering the fact that the elevation pattern is obtained when the antennas are set to vertical polarization, the reflections caused by the floor are probably the most plausible to be causing results distortion. At higher frequencies (2.5 and 5 GHz) the situation is different. Although the simulation and reality do not match too closely, which is probably caused by the fact that the separation between antennas was sufficient according to (2) but not ideal (see [8] for details), there is a good consistency between results obtained with and without the absorbers.

4. Conclusions
The authors of this paper administrated an experiment consisting in measurement of the radiation pattern of the horn antenna Rohde & Schwarz HF 906 inside a semi-anechoic chamber in order to explore how much the absence of damping elements on the chamber’s floor affects the obtained results at frequencies above 1 GHz. According to the obtained results it can be stated that if the antenna is directive enough,
especially at frequencies above 2.5 GHz, the effect of the absorbers placed on the floor of the semi anechoic chamber is negligible. The effect of the absorbers was observed only at the frequency of 1 GHz and vertical antenna polarization (measurement of the elevation pattern).

The authors believe that these findings can be useful for laboratory workers operating a semi-anechoic chamber, who occasionally need to perform high frequency antennas measurement.

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References
[1] IEEE-SA Standards Board 1979 *IEEE Standard Test Procedures for Antennas* chapter 4
[2] Nikolova N 2016 Basic Methods in Antenna Measurements (Hamilton: McMaster University)
[3] Pospisilik M and Soldan J 2014 Electromagnetic field distribution within a semi anechoic chamber *Proc. Int. Conf. On Circuits, Systems, Communications and Computers* (Santorini, 2014)
[4] Pospisilik M, Silva R, Adamek M 2016 Maple algorithm for damping quality of anechoic chambers evaluation *International Journal of mathematics and computers in simulation* 10
[5] Prochazka M 2005 *Antennas* (Praha: BEN)
[6] Latif S, Flores D, Rodriguez D, Solis M, Pistorius S and Shafai L 2015 A Directional Antenna in a Matching Liquid for Microwave Radar Imaging *International Journal of Antennas and Propagation* 13 10.1155/2015/751739
[7] Svacina J 2001 Basics of Electromagnetic Compatibility *Electrorevue* 21
[8] Silver S 1998 *Microwave antenna theory and design*
[9] Mallazhadeh A and Imani A 2009 Double-ridged antenna for wideband applications *Progress in Electromagnetics Research* 91
[10] Horn Antenna Calculator, online: [http://hornantennacalculator.blogspot.cz/p/calculator.html](http://hornantennacalculator.blogspot.cz/p/calculator.html)
[11] OTH Infra-Comm: EMI, EMC and EMP Solutions