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Environment Simulations for MEG measurements inside Reverberation Chamber

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Environment Simulations for MEG measurements inside Reverberation Chamber

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Abstract: *A specialized Reverberation Chamber is used to create physical models of real propagation environments. The project aims to simulate different real environments by altering the propagation parameters: plane wave incident angles, field amplitude statistics, polarization and time delay inside the chamber. This can be used to measure the MEG and also to evaluate diversity and MIMO concepts on communication terminals. So far it has been shown that the plane wave incident angles and the field amplitude statistics can be altered. Initial experiments has also shown that the polarization and time delay can be changed inside the chamber.*

Introduction

To be able to measure the real performance of mobile terminals used in multipropagation environments we need to measure the terminal in the user environment. It is unpractical and expensive to move around measurement equipment in different real user environments and the measurements are affected by temporary environment characteristics as for instance the weather and the time of year. This is why we have created the Scattered Field Chamber (SFC) which is a specialized Reverberation Chamber in which the propagation environment characteristics can be changed. The Reverberation Chamber, as shown in Figure 1, provides a stabile environment for repeatability and you are also able to control the measurement uncertainty to some extent. Diversity and MIMO concepts can also be relevantly evaluated in the SFC as well as measurements of the Mean Effective Gain (MEG) of antennas (terminals). The propagation environment parameters that are supposed to be controlled are, the 3D angular distribution of plane waves that incident on the terminal, the statistics of the plane wave amplitudes (and phase), the polarization of the incident plane waves and the time spread or power delay characteristics of the environment.

Figure 1. The basic Reverberation Chamber with dual mode stirrers.

The amplitude statistics
It has already been shown by Hallbjörner [1] that the amplitude statistics of the plane waves can be altered between a Rayleigh distribution and a Gaussian distribution. Everything in between these two is the Rice distribution with different parameter values. Figure 2 shows a measurement performed in a real environment [2] and Figure 3 shows how the distribution can be altered in a SFC with Hallbjörners method.

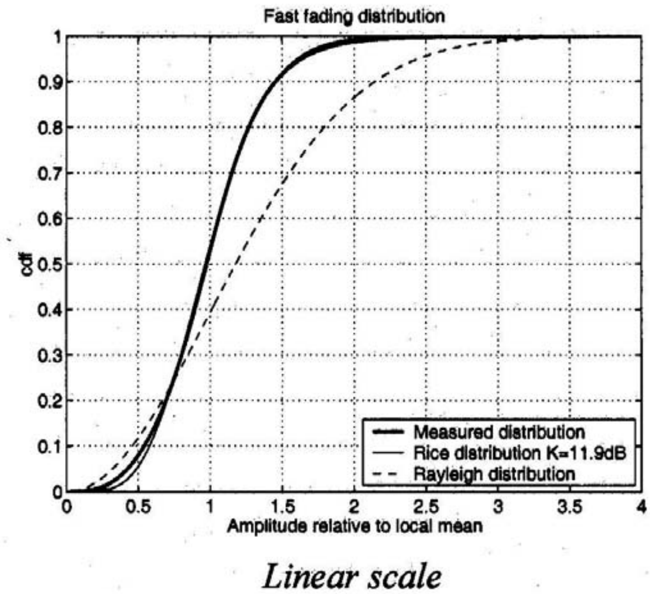

Figure 2. The amplitude statistics of a real environment [2].

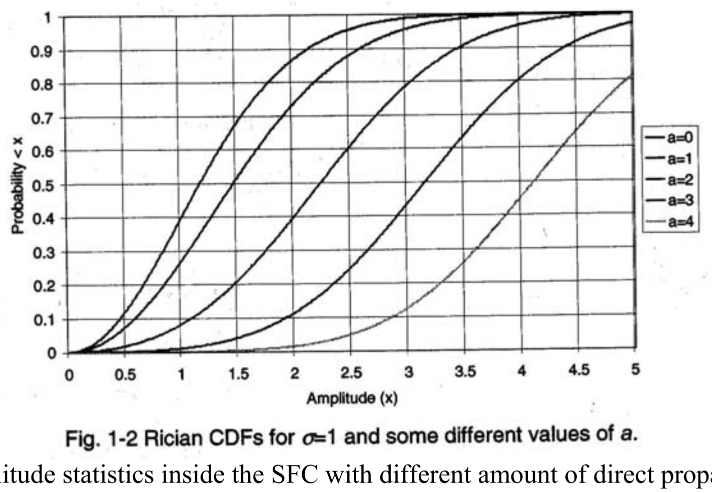

Figure 3. The amplitude statistics inside the SFC with different amount of direct propagation (LOS) [1].

The 3D distribution of plane waves
Experiments have been made with two different methods, the single absorber method and the shielded box method. Starting up with the single absorber method we tried to reduce the amount of plane waves from two directions by placing absorbing plates in these directions. The receiving antenna was rotated 360 degrees in the horizontal plane and the received power was measured for different angles (every 22.5 degrees) of the receiving antenna which in this case was a broadband horn antenna. The results for different frequencies are shown in Figure 4 and Figure 5, Figure 4 is measured without absorbers and Figure 5 is measured with two flat 60×60 cm absorbing plates placed on opposite walls in the directions 0 and 180 degrees inside the chamber.

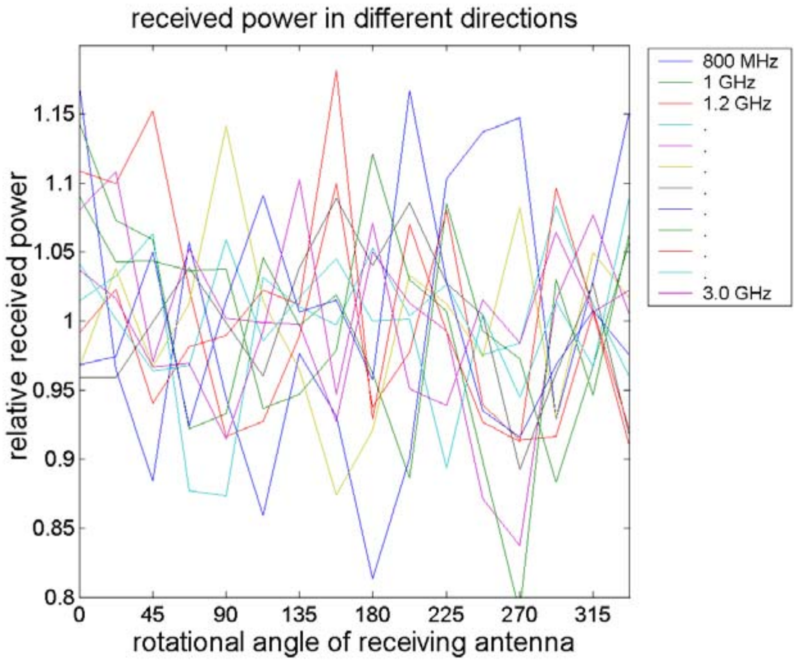

Figure 4. The received power as a function of rotational angle of the receiving antenna, no absorbers.

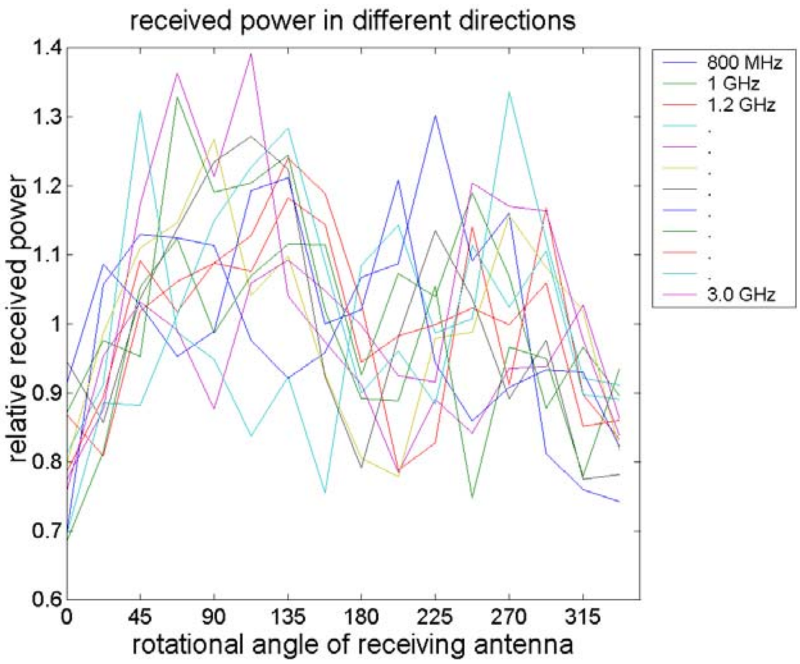

Figure 5. As Figure 4 but this time with absorbers in the directions 0 and 180 degrees.

As we can see the effect of the absorbers is visible but very small. Measurements of real environments [2][3] show that the received power can change as much as 20 dB depending on the direction of reception. A new experiment was carried out, this time with a shielded anechoic box that was placed inside the chamber and the receiving antenna was placed inside the shielded box as shown in Figure 6. Apertures in the anechoic box was used to control the directions of the incident waves upon the receiving antenna which in this case was a WLAN antenna with an approximate directivity of 8 dBi. The result for quadratic apertures of size 8×8 cm in the directions 0 and 180 degrees is shown in Figure 7.

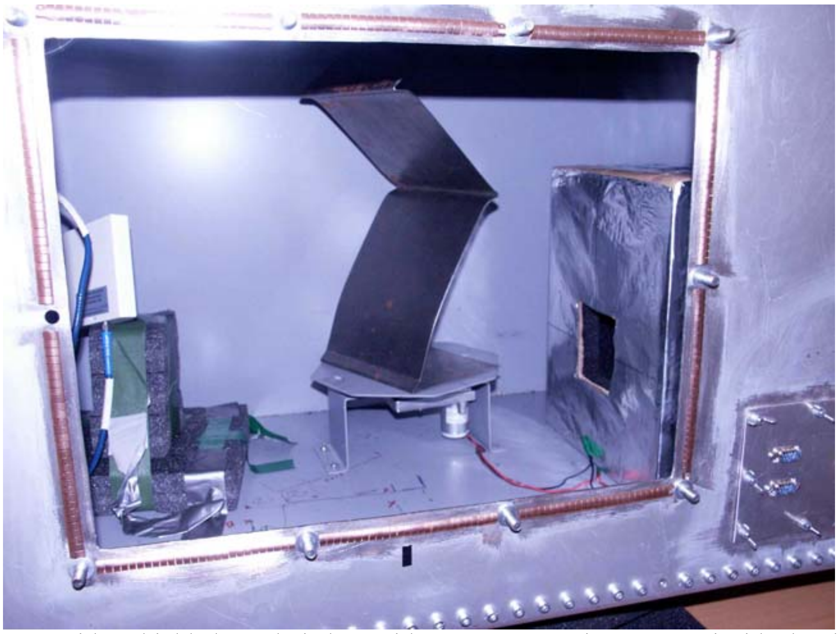

Figure 6. A SFC with a shielded anechoic box with apertures, receive antenna inside the shielded box.

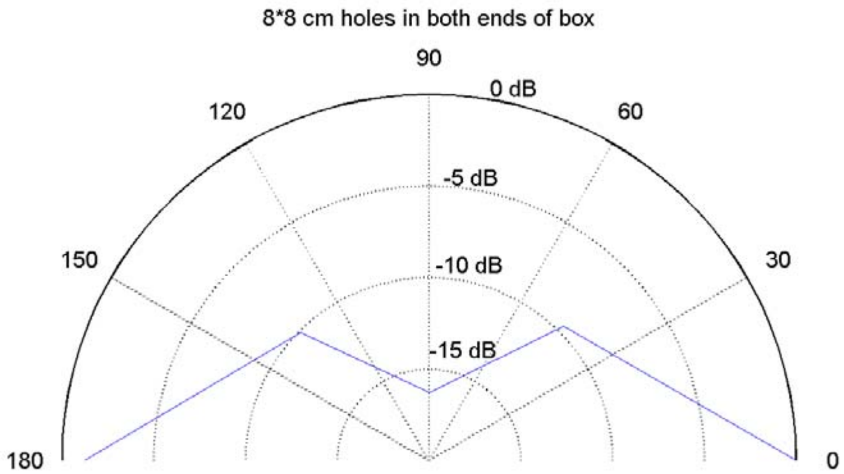

Figure 7. The received power as a function of rotational angle of receive antenna.

As we can see the largest difference in received power is just above 15 dB. Since the receiving antenna directivity is finite and in this case relatively low this will affect the measurement results in a negative way. The antenna will receive quite a lot of energy direct from the aperture even though it is directed away from it. In order to examine how the antenna directivity affected the measurement we performed a similar experiment, this time in a larger Reverberation chamber and with a larger shielded, anechoic box as shown in Figure 8. In this experiment the aperture was circular with a diameter of 6 cm and we used two different kinds of receive antennas, one broadband horn antenna with an approximate 3dB lobe angle of 60 degrees and one standard gain horn antenna with an approximate 3 dB lobe angle of 30 degrees. Figure 9 and 10 show the result for the broadband antenna and the standard gain antenna respectively. As we can see the assumption that the receiving antenna directivity will affect the result in a negative way is true.

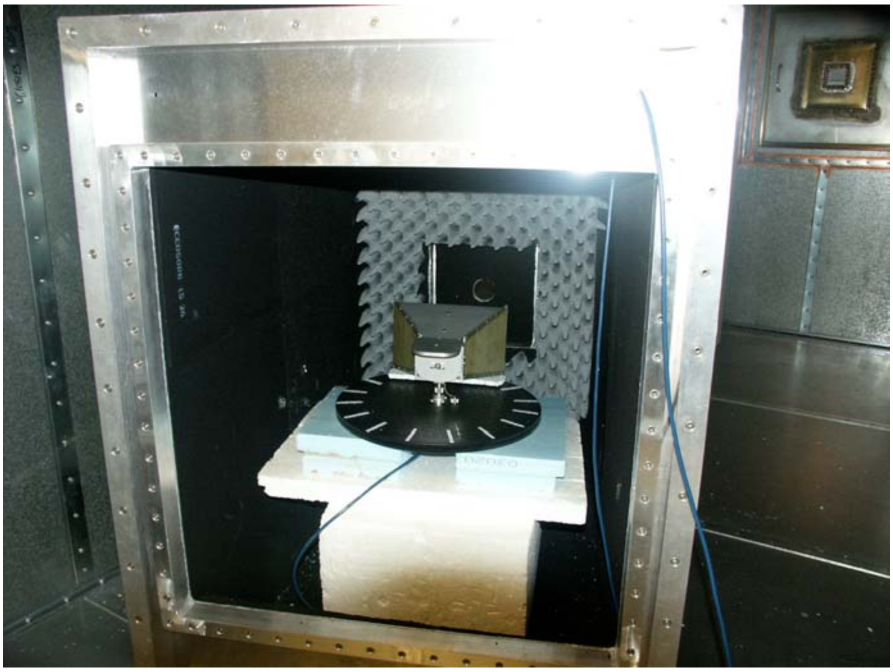

Figure 7. The broadband horn antenna inside the shilded anechoic box with a circular aperture.

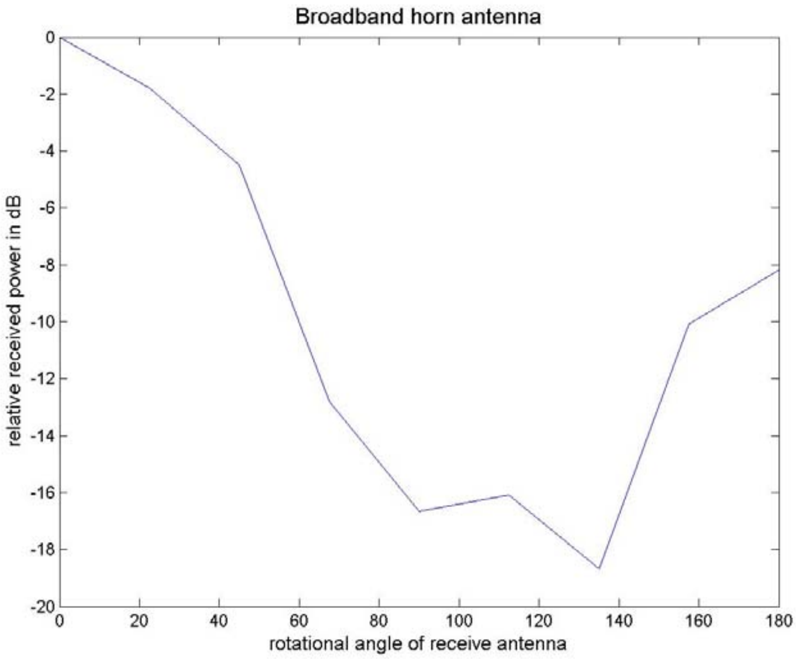

Figure 8. The relative received power for different angles of the broadband antenna.

The amount of change is now around 20 dB and probably limited due to the finite attenuation of the absorbers but this is in the same order as the results from the measurements made in the real environments. The apertures in the shielded box can also be designed to control the polarization of the plane waves from the different directions. This can be made with polarization filters placed in the aperture or by the geometry of the aperture it self.

Conclusions
The method of controlling the 3D plane wave distribution with a shielded anechoic box with apertures seems to be suitable to model real environments. Also the fact that the apertures can be designed to control the ploarization of the plane waves from the different directions is a positive effect.

Limitations in antenna directivity and absorber attenuation are factors that affect the measurement results in a negative way.

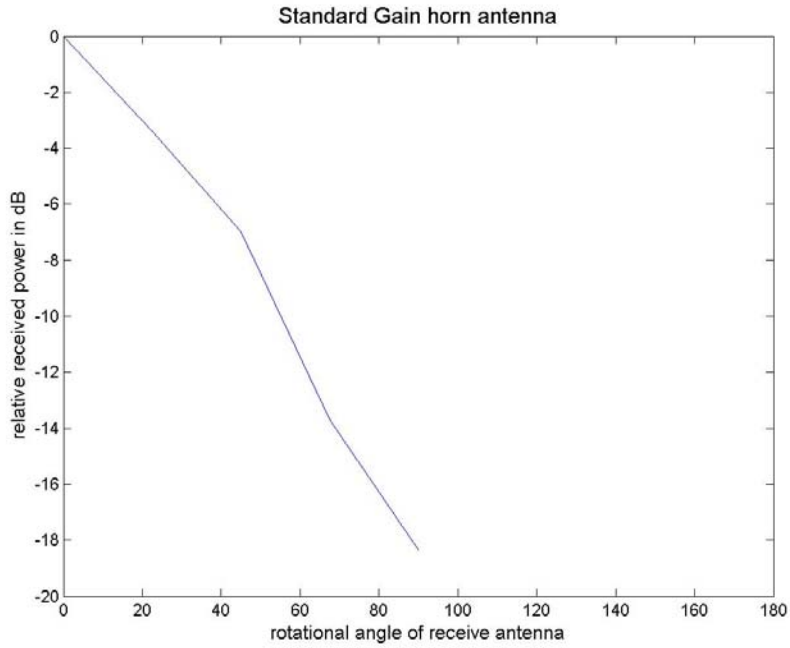

Figure 9. The relative received power for different angles of the standard gain antenna (only 0 to 90 degrees).

Future work

Measurements of the apertures ability to control the polarization is to be performed. Also numerical simulations is made to be able to estimate the directional properties of the apertures without the effect of finite antenna directivity and absorber characteristics. Finally the time spread or power delay is to be changed inside the SFC. Initial measurements have shown that this parameter is possible to alter but it is not examined to which extent this can be done.

References

[1] Madsén, Hallbjörner, "Reverberation Chambers for Mobile Phone Antenna Tests", *The 2001 Reverberation Chamber, Anechoic Chamber and OATS Users Meeting,* Bellevue WA USA, 2001.

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