Correlation Coefficients of MIMO Antennas in Reverberation Chamber

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***Abstract*—Correlation coefficient of a 2x2 MIMO system was found with various configurations in reverberation chamber (RC) to emulate the effects of polarization, pattern of elements, and environment conditions in real-life communication channel. Results show that the correlation is very sensitive to the polarization, antenna spacing, and environmental conditions.**

Keywords—correlation coefficient, polarization, MIMO, reverberation chamber (RC).

I. INTRODUCTION

A multiple-input-multiple-output (MIMO) system capable of meeting the demand for high capacity in wireless communications has received much attention in recent years. One of the important parameters in measuring the performance of MIMO systems is the correlation coefficient. This is a parameter that measures the independence of the signal reception function on a MIMO channel. The MIMO channel is obviously characterized by antenna configuration and propagation environment. Antenna correlation depends on the antenna configuration, such as antenna type, antenna spacing, solid angle, and propagation pattern. Reverberation chambers have been widely used to characterize MIMO systems in multipath environments. However, it is not known how the RC environment is affected by the determination of the correlation coefficient. In this paper, we investigate correlation coefficient of a 2x2 MIMO system in a reverberation chamber loaded by an absorber to emulate a real environment.

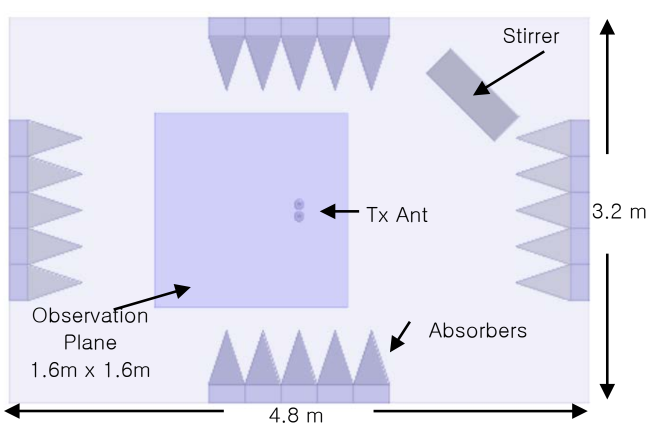


Fig. 1. The geometry of the reverberation chamber with biconical antennas, a mode stirrer, and an observation plane.

II. SIMULATION SETUP

Fig. 1 shows the shape of the reverberation chamber considered, with dimensions of 4.8 (W) x 3.2 (L) x 2.8 (H) m^3, and a vertically z-axis folded mechanical stirrer is included in this chamber. A vertical six-paddle metallic stirrer is incrementally rotated by the angular step of 15° between 0° and 345°. The RC was simulated for the 500MHz to 2.5GHz band using the finite difference time domain (FDTD) method.

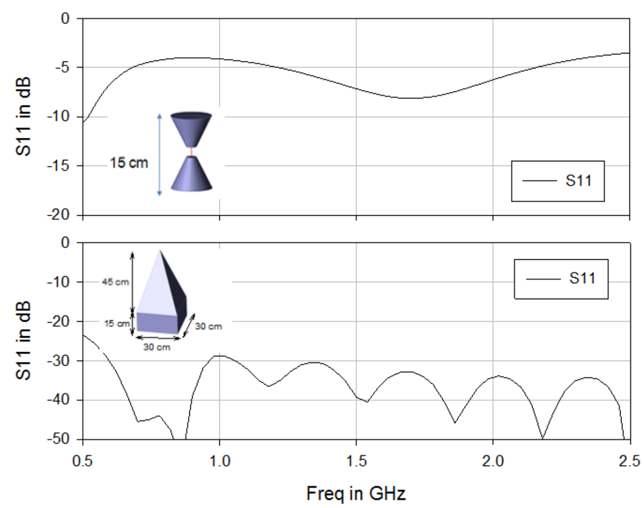
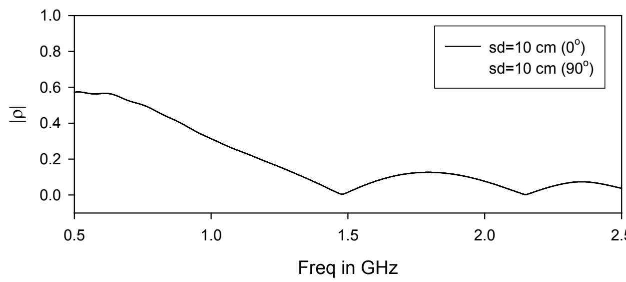


Fig. 2. Return loss of biconical antenna and reflection coefficient of a pyramidal absorber.

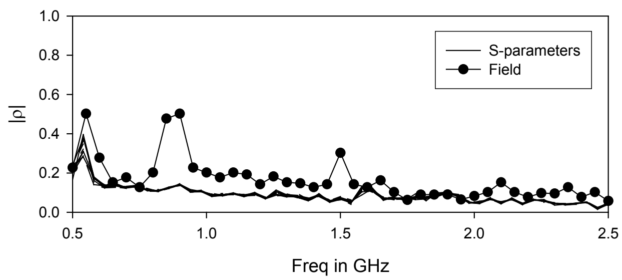
In the center of Fig. 1, there are two biconical antennas with a cone angle of 50° and a total length of 15 cm. Fig. 2(a) shows the return loss for the 0.5-2.5 GHz band. The four sidewalls of the RC have a 5x5 pyramid absorber attached to control the number of multipath components and the power spread delay in a wireless communication environment. The dimensions are shown in Fig. 2(b), with a permittivity of 3.5 and a conductivity of 0.35 S / m. The reflection coefficient of the absorber was less than 20 dB for the 0.5-2.5 GHz band, introduced in [1]. Instead of the correlation coefficient by the three-dimensional radiation pattern which cannot be obtained within the chamber loaded by the loss absorber, the correlation coefficient of equation (1) can be found by the S-parameter.

$$\rho = \frac{|S_{11}^{*}S_{12}+S_{21}^{*}S_{22}|^2}{(1-|S_{11}|^2-|S_{21}|^2)(1-|S_{22}|^2-|S_{12}|^2)} \quad (1)$$

This equation applies only to MIMO arrays composed of high efficiency antennas [2].



(a)

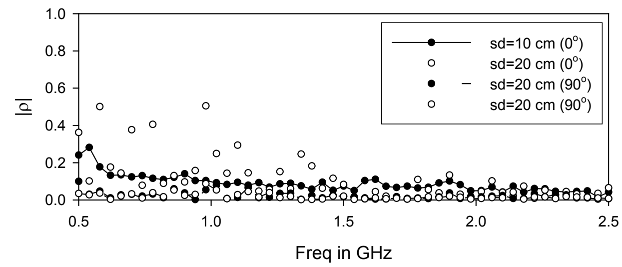


(b)

Fig. 3. Correlation coefficients between two biconical antennas (separation distance = 10 cm), (a) in free space, (b) in RC.

III. Analysis of Correlation Coefficients in the RC

Fig. 3(a) shows the correlation coefficient between two biconical antennas at 10 cm interval in free space for verification. As shown in [2], the correlation coefficient of the periodic zero is for the frequency range for the parallel polarization and null for the entire frequency range for the orthogonal polarization [3]. Fig. 3(b) shows the correlation coefficients for antennas of the same configuration in the RC. For all 24 stirrer angles, we obtained correlation coefficients with no markers and the values are almost identical to those shown. From this fact, it can be seen that the rotation of the stirrer does not affect the performance of the MIMO system. Fig. 3(b) shows the correlation coefficient between the 2-D field(E_z) generated by each of the two antennas in the observation plane(1.6m x 1.6 m) of Fig. 1 for comparison. The difference is that eq. (1) does not consider the efficiency of the antenna. However, there is no problem in predicting the performance trend of the MIMO system for the frequency variation. Fig. 4 shows the correlation between two biconical antennas according to changes in absorber conditions, spacing, and polarization in the RC. The correlation values between the two antennas are shown for parallel and perpendicular polarizations for two separation distances of 10 cm and 20 cm in Fig. 4 (a). As expected, perpendicular polarization is less correlated than parallel one. However, due to the environmental effects in the RC, it was slightly larger than complete zero in free space.



(a)

(b)

Fig. 4. Correlation coefficients between two biconical antennas, (a) for change of separation distance, (b) and loading conditions.

A statistically random characteristic appears for two spatial variations between two parallelly polarized antennas in the low frequency domain. Unlike free space, it is the result of RC environmental conditions. Fig. 4 (b) shows the correlation coefficient when changing the number of absorber walls in the RC. The correlation coefficient does not change according to the stutters' angle in Fig. 2 (b), but it changes depending on the condition of the absorber.

IV. Conclusion

Correlation coefficient of a 2x2 MIMO system was investigated for several antenna configurations in reverberation chamber (RC) to emulate polarization, separation distance of elements, and environment conditions in real-life communication channel. Results show that the correlation is very sensitive to the polarization, antenna spacing, and environmental conditions.

Acknowledgment

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