Correlation Between Far-field Patterns on Both Sides of the Head of Two-port Antenna on Mobile Terminal

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***Abstract*—We present an electromagnetic simulation of a practical mobile terminal with a two-port MIMO antenna on left and right sides of the head. The computed far-field patterns include the effect of head and hand phantoms. We show that the far-field patterns on the two sides are strongly correlated if they are presented in the coordinate system of the phone, but they are completely uncorrelated in the coordinate system of the environment.**

I. Introduction

Several studies related to different user practices of holding a single-port mobile terminal have been performed during the last decade, see e.g. [1]. However, this has not been extensively done for the latest LTE mobile handsets that have multi-port antennas with MIMO (Multiple-input Multiple-output) technology. It is still unclear how different user practices will affect the performance of these mobile terminals. Therefore, it is important to re-evaluate the impact of different user practices, such as holding handsets on both sides of the head and to check how far-field patterns change from one side of the head to the other. The study of the latter is the purpose of this paper.

Reference [2] proposed new systematic approach to dealing with user statistics via considering an ensemble of arbitrary users in a random Line-of-Sight (LOS) environment. It is argued that the horizontal plane of far-field function of a phone on the left side of the head is similar to the vertical place of far-field function of the same phone on the right side of the head, and vice versa. This makes the phone experience incoming waves in the horizontal plane as if they come from all directions in space, when observed over time from positions on both sides of the head. This means that the environment appears 3-D random, even if it is not. In other words, the purpose of this paper is to show that the far-field functions on the two sides of the head are correlated when presented in the coordinate system of the phone. Both the coordinate system of the environment with vertical v-axis, and the coordinate system of the phone are shown in Fig. 1 (a) for a user holding the phone on the left and right sides. We see that the xyz-coordinate system of phone on both sides of the head is oriented 90 degrees with respect to each other while the uvw-coordinate system of environment is the same on both sides.

Therefore, we will compute the far field functions of a mockup of a multiport terminal on both sides of the head, and we will characterize these to see how they change.

II. EM Simulations Using CST Microwave Studio

EM simulations are performed using CST Microwave Studio. The performance is evaluated in terms of S-parameters and far-field patterns. The multiport mobile terminal model is a practical mockup of a mobile handset with 2-port MIMO antenna. The antennas used in this mobile terminal are Planar Inverted-F Antennas (PIFA) operating in the frequency ranges of 0.7–1.0 GHz and 1.7–3.2 GHz. The PIFA antennas are located along each short side of the mobile terminal. The terminal is located on either side of the head phantom according to the standard cheek position [3].

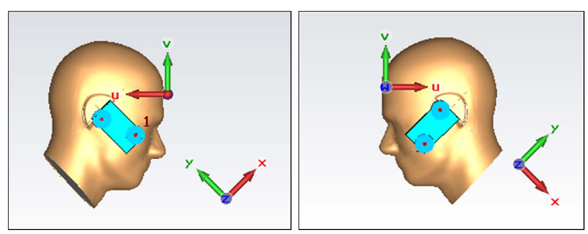

Figure 1 (a). SAM head phantom, hand phantom, and phone mockup in CST on both sides of the head. The environment uvw-coordinate system and phone xyz-coordinate system are shown.

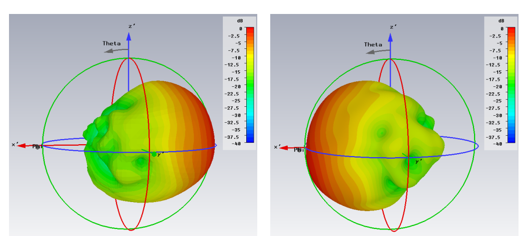

Figure 1 (b). Simulated absolute value of E-field from port 2 on phone mockup on left and right sides of head at 2.5 GHz. Polarization is not visible for such plots.

III. FAR-FIELD PATTERNS IN DIFFERENT COORDINATE SYSTEMS

In Fig. 2(a) and 2(b) we compare the simulated far-field patterns for phone on both sides of the head in the coordinate system of the environment. We see that when the phone is on the left side of the head, the horizontal E-field component (i.e. E-phi) in the vertical plane have a similar pattern as the vertical E-field component (i.e. E-theta) in the horizontal plane when the phone is on the right side, and visa versa. In other words, the patterns are diagonally similar in Fig. 2 (a) and Fig. 2 (b), which we want to show.

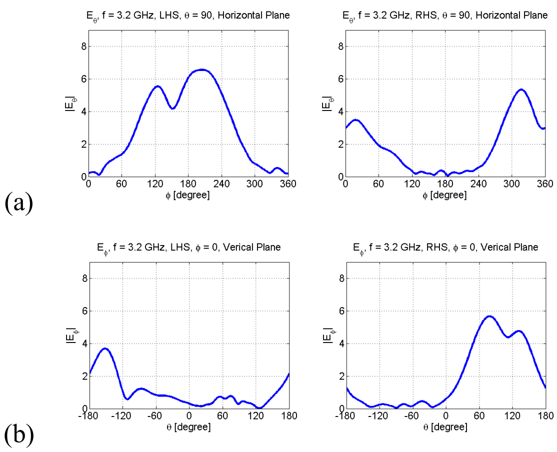

Figure 2 (a). E-theta component in horizontal plane of mobile phone on left and right sides of head phantom, respectively. Figure 2 (b). E-phi component in vertical plane of mobile phone on left and right sides of head phantom, respectively.

IV. FAR-FIELD CORRELATIONS USING VIRM-LAB

We will now study the similarities between the far-field patterns on both sides of the head in more detail, by evaluating different correlation integrals using the MATLAB based tool called ViRM-lab [4]. The formulas to calculate complex and envelope correlation are given in [5].

V. RESULTS & DISCUSSION

The results for complex correlation are presented in Fig. 3. It shows that the far-field patterns on both sides of the head are uncorrelated when they are presented in the coordinate system of the environment; see Fig. 3 (top). In other words, this means that the LOS channel experienced by the mobile terminal on right side of the head will be completely different from the left side of the head. But the same far-field patterns are correlated when they are presented in the coordinate system of the mobile terminal; see Fig.3 (bottom). This also shows that the assumption in the introduction is correct. The results also show that the effect of hand makes the two patterns less similar.

VI. CONCLUSION

The conclusion is that the shape of the far-field function of the studied mobile terminal remains similar when it is used on either side of the head, if the coordinate system of the presentation is aligned to the mobile terminal. However, the coordinate system is rotated with respect to the environment, so the far-field function in the horizontal plane on one side becomes a far-field function in the vertical plane on the other side, and with orthogonal polarizations. This may not be generally valid, but it is logical and we have proven it for this specific mobile phone mockup. The effect of the hand phantom changes the correlation between the two orthogonal planes on the two sides.

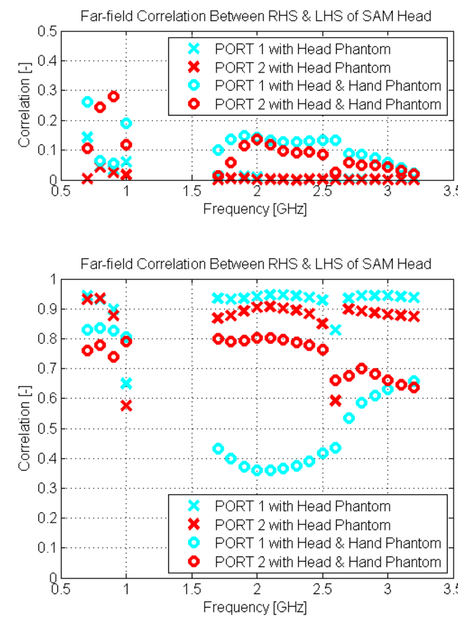

Figure 3. Complex correlation between far-field functions on right and left sides of the head when the coordinate system is aligned to the environment (top) and to the terminal (bottom).

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