Measurements and Numerical Simulations to Enhance the assessment of Antenna Coupling

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***Abstract*— A post-processing procedure has been presented in recent publications to create an accurate numerical model of a measured antenna [1-8]. The post-processing is based on the equivalent current technique as implemented in the INSIGHT software from MVG [4]. Such models are applicable in standard commercial Computational Electromagnetic (CEM) solvers to determine the performance of measured antennas situated in complex environments [9-14]. The method also gives an accurate assessment of the resulting element coupling if the measured antenna is duplicated and used in array configuration as reported in]3]. In this paper, a wide-band numerical model of the measured antenna is presented, improving the accuracy of the coupling assessment. The finding are supported by radiated and conducted measurement on the single element and the array configuration.**

I. INTRODUCTION

Near Field (NF) models of measured antennas is recently available in most CEM solvers [9-14]. The numerical model of the antenna is determined by measurement post-processing using equivalent currents, implemented in the commercial tool INSIGHT [4]. This method enable the import of measured data to enhance numerical simulations of antenna placed in complex and/or large scenarios. Validation of the method by experiment considering different antenna placement scenarios are reported in [1-3]. Using this innovative approach, the numerical models derived from the antenna measurement, can be imported in commercial CEM tools and coupling with other antennas can be simulated. No knowledge of the mechanical and/or electrical parameters of the measured antenna is needed in the determination of the equivalent numerical model.

The aim of this paper is to investigate the applicability of this method in antenna coupling assessment. Initial investigations of a three-element array in H/V polarization have shown good assessment accuracy of element coupling as reported in [3]. New array elements with focus on mechanical accuracy, to minimize possible differences between elements, are manufactured for this study. To increase the element coupling the array polarization in this study is slant ± 45°.

In this study, the central element of the three-element array has been considered as the unknown antenna. The entire array has been measured and simulated using full-wave tools in the validation of the method.

As input for the coupling investigation, the radiation pattern of the central array element is measured in isolation. The measured data constitutes the input for post-processing to create the source antenna model/ Huygens box based on equivalent currents. The source antenna model is installed in the array with the lateral elements and simulated using a standard CEM tool [9]. Both inter-element coupling between the ports and the embedded patterns are simulated. The accuracy of the analysis is investigated by comparing the simulations with radiated measurements on the full three-element array.

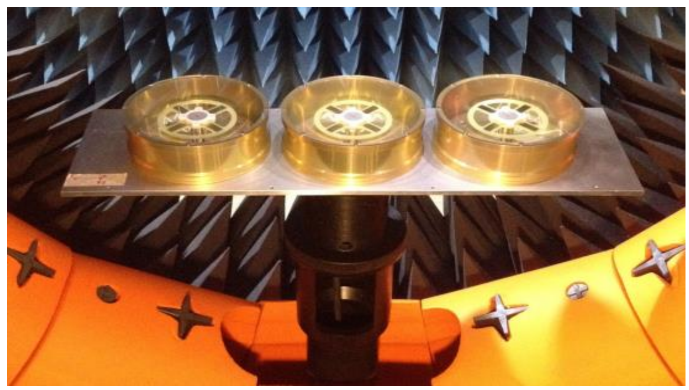

Figure 1. Three-element array in dual slant ± 45° polarization during measurement in SL18GHz.

II. THE WORKING PROCEDURE

The validation of the working procedure combining measurements of a single elements and simulations of the coupling with other elements consists of the following steps:

- Measurement of the single element of the array (in isolation) and creation of the measured NF source representation.
- Import of the NF source in the CEM tool and placement in the array configuration.
- Numerical simulation of the antenna coupling between the measured model and the other two elements of the linear array.

A. *Creation of the measured NF source representation*

The single element of the array consisting of a cavity-backed crossed-dipole antenna, see Figure 2 (left)-(center), has been measured in the MVG StarLab measurement system [15] in the frequency range [1.7-2.2] GHz. -45° port is fed during the measurement. NF equivalent currents representation of the antenna, see Figure 2 (right) at five frequency points (1710MHz, 1825MHz, 1940MHz, 2055MHz and 2170MHz) have been determined. The +45° port is loaded with 50 ohms. The frequency points under test have been selected in the frequency range where the antenna efficiency is maximized in order to get as much information as possible from the dynamical range of the radiation pattern. In the previous study only three frequency points have been used, so at this new step of the study two additional points have been considered (1710MHz and 2170MHz) to improve the accuracy in the evaluation of S-parameter.

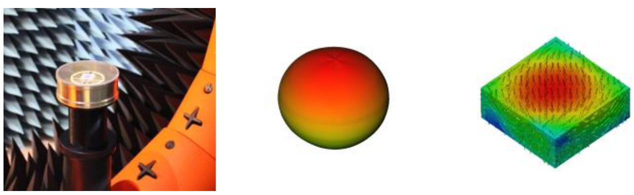

Figure 2. Source preparation procedure: (left) array single element in the StarLab measurements system; (center) NF radiation pattern @1940MHz; (right) equivalent electric J currents, Huygens box @1940MHz

B. *Numerical simulation*

Measured NF source (at 5 frequencies) has been imported in the CEM tool [9]. The central element of the CAD model of the array is replaced with the measured NF source (see blue box in Figure 3). In Figure 3 antenna ports are illustrated in red colors. Ports 1, 3, 5 are polarized at -45° and ports 2, 4, 6 are polarized at +45°. The position of port 1 and 2 in the equivalent model should be known.

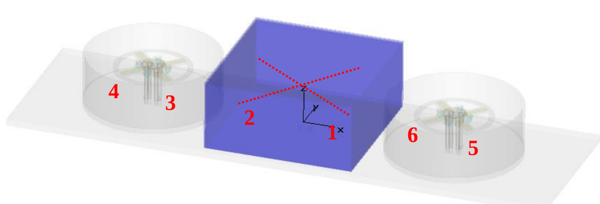

Figure 3. Intallation of the measured source in the simulated model of the array

III. RESULTS

Comparison of directivity radiation patterns for port 1 (-45°) measurement of the array (meas) and simulation with the measured NF source (link), for cut phi=0° @1940MHz, is shown in Figure 4. The good agreement between the two curves shows the validity and the accuracy of the combination of measurements and simulation for this particular test case.

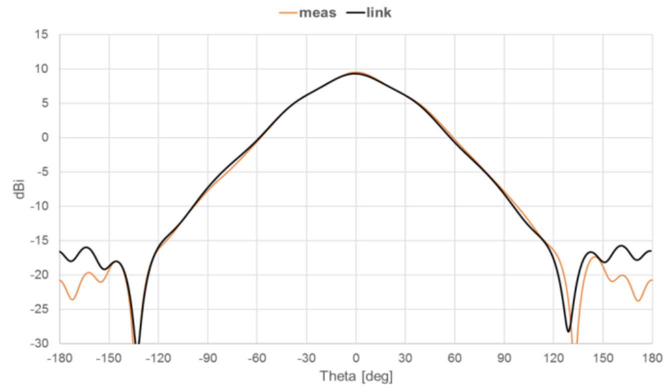

Figure 4. Directivity pattern comparison, cut phi=0° @1940MHz, between measurent of the array (meas) and simulation with the measured NF source (link)

The coupling of the measured central element with the other element of the array is simulated, port 1 (-45°) is fed and ports 3, 4 5 and 6 of the other elements are receiving. Comparisons of simulation and measurement of the entire array (reference) are reported in Figure 5.

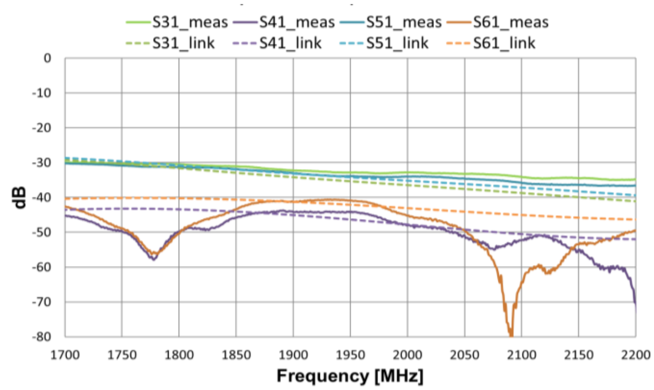

Figure 5. Antenna coupling between the central element (port 1) and the other two side elements (ports 3-6); measurement (meas) and simulation using the measured NF model of the central elemenet (link)

Comparison in terms of coupling average values over the range [1.7-2.2] GHz are reported in Table 1. Deviation between the measured and simulated S31 and S51 corresponds to 1.40dB and 2.19dB and it is reduced with respect to the results from the previous study (6.28dB and 2.75dB) [3].

TABLE I. ANTENNA COUPLING: AVERAGE VALUES

	S31	**S41**	**S51**	**S61**
Measured [dB]	-49,85	-32,41	-48,88	-33,52
Link (NF model) [dB]	-51,25	-36,66	-46,74	-35,20

IV. CONCLUSION

A new method combining numerical simulation and antenna measurements applied to the evaluation of antenna coupling has been presented. A new design of the antenna under test has been used during the validation and thanks to a frequency, refined electromagnetic model from INSIGHT an improvement of the accuracy of the results has been achieved.

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