Analysis of Measurement Probe Spherical Higher Order Modes based on Equivalent Currents

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***Abstract*—Probe correction in Spherical Near Field (SNF) measurements is typically performed during the NF/FF transformation assuming a probe with limited |μ|=1 spectrum [1]-[2]. This requirement leads to challenging probe designs, especially if the required bandwidth is wide. For this reason, in many practical cases, higher order spherical modes could be radiated.**

In this paper, the source of higher order spherical modes of the MVI SP1100 probe is investigated using INSIGHT software [3] which reconstructs equivalent currents starting from the measured NF. The equivalent currents associated to higher order modes have been computed on a conformal geometry encompassing the probe. In this way, the origin of such higher order modes has been evidenced. Knowledge of these sources are useful to improve future probe designs.

Keywords—antenna measurements, first order probe, spherical wave expansion, equivalent currents.

I. Introduction

In this paper the spherical modal content of the SP1100 first order probe, designed by MVI and shown Fig.1, is analyzed in detail in order to understand the source of higher order modes.

In [7], it has been shown that excitation errors in the beam forming network (BFN) generates higher order spherical modes. Another interesting aspect to be analyzed in probe design is the influence of the absorber collar that in practical SNF measurement scenario is used in order to limit the reflections from the supporting structure [8]. Understanding the impact of these source of errors on the spherical mode content is of primary importance in order to optimize the probe design.

The analysis of the currents on the probe surface is a key point for an exhaustive finding the source of higher order mode. For this reason, the analysis have been performed using the commercially available INSIGHT software [3]-[5] that, starting from the measured Near Field (NF), consents computing equivalent electric and magnetic currents (EQC) on an surface fully enclosing the AUT/DUT.

In the study reported in this paper, spherical modes with azimuth indices |μ|≠1, have been isolated from those having indices |μ|=1 and the corresponding EQC have been computed on a surface conformal to the probe shape deriving interesting information regarding the origin of higher order modes.

II. Analysis of the MVI SP1100 First Order Probe

The MVI SP1100 is a wideband and electrically small L-band first order probe working in the frequency range 1.1-2.0 GHz in dual linear polarization. The probe consists of a quad-ridge wide band dual polarized orthomode junction (OMJ) [6] feeding a conical aperture. Such probe has been calibrated in the MVG SG64 spherical multi-probe system sited in Paris as shown in Fig. 1 (left). As can be seen the circular absorber collar and support structure has been included in the calibration as integral part of the probe. The probe was characterized in terms of spherical mode spectrum. The measured spherical mode spectrum @ 1.25 GHz, represented by the Pn and Pm curves, is illustrated in Fig. 1 (right). As can be seen from the Pm-curve, spherical modes of higher order, |μ| ≠ 1, are well below the -35dB threshold, as expected from the predicted performances.

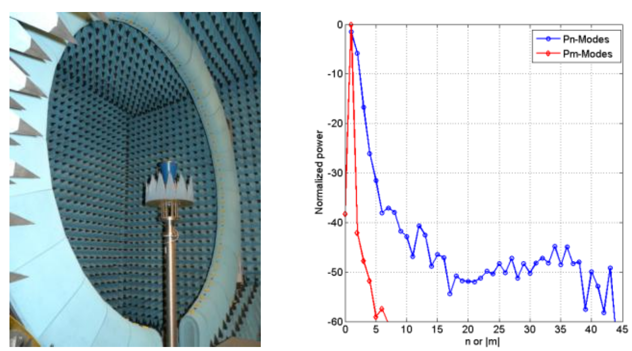

Fig. 1. MVI SP1100 probe during calibration in SNF in MVG SG64 (left); Measured spherical mode spectrum @ 1.25 GHz (right).

Despite the low level of the higher order modes, it is interesting to analyze them in order to understand if they are directly radiated by the aperture or generated by the interaction between the probe itself and other probe parts such as the absorber collar. The outcomes of such analysis could then be taken into account for further optimization of the probe performance in future design.

Using a combination of spherical mode filtering and equivalent currents, the origin of higher order spherical modes in the SP1100 probe has been investigated. Starting from the spectrum shown in Fig. 1 (right), different spherical mode subsets to be analyzed, have been isolated from the full probe spectrum using band-pass filtering. The reduced spectrum is used as input to EQC processing using INSIGHT. The EQC associated to a particular subset of spherical modes have thus been computed on an equivalent surface conformal to the shape of the SP1100. The currents illustrate the origin of the reduced spherical mode spectrum.

In order to find the origin of the most significant |μ|-modes, three different subsets have been selected for the analysis: $|\mu| = 0$, $|\mu| = 2$ and $|\mu| > 2$. The corresponding equivalent currents are shown respectively in Fig. 2, Fig. 3 and Fig. 4.

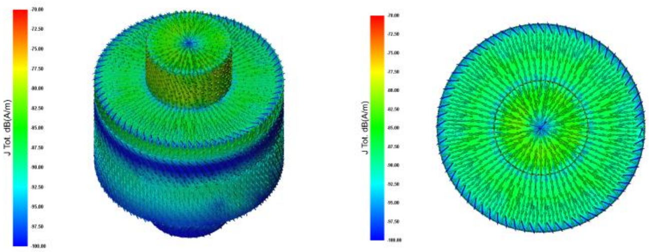

Fig. 2. Equivalent Currents @ 1250MHz associated to $\mu = 0$ spherical modes only. 3D-view (left); top-view (righ).

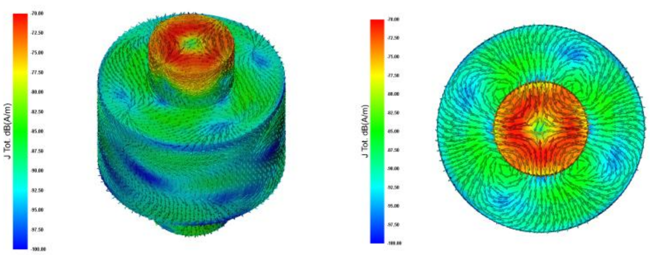

Fig. 3. Equivalent Currents @ 1250MHz associated to $|\mu| = 2$ spherical modes only. 3D-view (left); top-view (right).

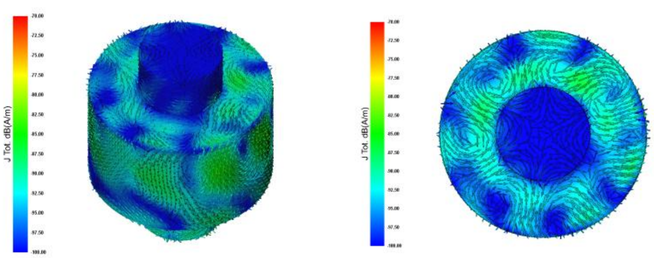

Fig. 4. Equivalent Currents @ 1250MHz associated to $|\mu| > 2$ spherical modes only. 3D-view (left); top-view (right).

Despite the low level of such equivalent currents (approximately 55dB below the EQC associated to the dominant mode - not reported here due to the limited length of the paper) it possible to well identify their shape and origin.

In particular, observing the EQC associated to the $|\mu|=0$ spherical modes (Fig. 2), it is possible to recognize the shape of the undesired TM_{01} circular waveguide mode [9]. The very low TM_{01} modal excitation is compatible with expected excitation errors in the BFN. The short probe and inverted ridge structure is unable to attenuate significantly the propagation of this mode which is therefore radiated by the aperture and then reflected/diffracted by the absorber collar.

A similar argument can be applied to the EQC associated to the $|\mu|=2$ spherical modes (Fig. 3). In this case, due to excitation error in the BFN, a TE_{21} circular waveguide mode [9] is radiated by the aperture and then reflected/diffracted by the absorber collar. The origin of these modes are therefore likely excitation errors more than interaction between probe aperture and absorbers.

Finally, as can be seen from the EQC shown in Fig. 4, the $|\mu| > 2$ spherical modes are not due to aperture radiation but to the field scattered by the absorber collar. In fact, it is clearly highlights that such contributions are distributed as hot spots on the absorber collar only.

III. Conclusions

In this paper, the spherical modal content of the SP1100 first order probe has been analyzed in detail in order to understand the source of $|\mu|\neq 1$ modes. The investigation has been performed using the commercially available INSIGHT [3] software and measured probe calibration data from the MVG SG64 spherical multi-probe system sited in Paris. Starting from the spherical NF measurement at 1250 MHz, the spherical modes with indices $|\mu|=0$, $|\mu|=2$ and $|\mu| > 2$ have been isolated and the corresponding equivalent currents have been computed on a surface conformal to the probe shape.

The relation between undesired waveguide modes and radiated spherical higher order modes have been analyzed pointing out that the guided modes are caused by excitation errors in the BFN. It has been thus observed that the most significant higher order modes ($|\mu|=0$, $|\mu|=2$) are directly radiated by the aperture. The remaining azimuth mode are instead due to the field re-radiated by the absorber collar.

The outcome of this paper represent an important input for further optimization of probe performances in future designs.

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