Antenna Measurement Systems using Multi-Probe Technlogy

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***Abstract*— Modern antennas and applications are expanding the frequency range towards both lower and higher frequencies while demanding very rapid development and testing cycles. A fast, reliable and accurate way to exhaustively determine antenna and device performance is based on near-field measurement techniques combined with probe array technology.**

This paper reviews recent developments in multi probe antenna measurements technology and show new application examples. In particular, the results of a challenging measurement of a VHF low-directive antenna performed in a hemispherical multi-probe system are reported.

Keywords—Antenna measurements, near-field, multi-probe, low frequency

I. Introduction

Near Field (NF) antenna measurements represent a reliable and accurate way to characterize the performance of an antenna or device under test (AUT/DUT). In a NF system the field radiated by a DUT is sampled at a relatively close distance and then is mathematically transformed to Far Field (FF) with NF/FF algorithms [1]. For this reason, NF systems are much more compact with respect to system where the field radiated by the antenna is measured directly in FF. Indeed, the main advantage of a NF system is that it can be easily installed in a anechoic chamber in order to perform the measurement in a controlled environment. On the other hand, the NF/FF algorithms require a full set of NF input data with a consequent increase of the measurement time.

Multi-probe systems [2]-[3] are NF measurement ranges designed in order to overcome the limitations related to the high acquisition time of the NF (single-probe) systems. In a multi-probe system one mechanical axis is in fact replaced by an array of electronically scanned probes. Instead of recording data at discrete positions by moving a single-probe antenna, the system measures at each position with a different probe allowing a drastic reduction of the testing time.

An example of implementation of a (spherical) multi-probe system if shown in Fig. 1. As can be seen the elevation axis is replaced an array of probes (arch). In particular (in this case), one half of the arch (left) is filled smaller probes working in the range 0.4-6.0 GHz. The bigger probes located in right side of the arch are instead intended for measurement at lower frequencies (70-400 MHz). The DUT is typically mounted in the center of the arch on a supporting mast, in this case, made of styrofoam in order to limit the coupling with the DUT. The electronic scanning of the probe is usually based on the Advanced Modulated Scattering Technique (A-MST) well described in [4]. Recent implementation of multi-probe systems are instead based on a distributed switching network.

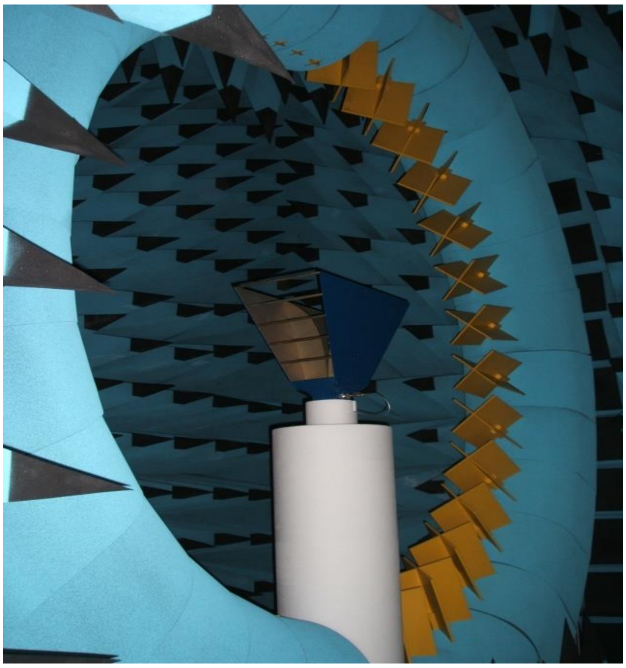

Fig. 1. Example of spherical multi-probe system.

As an example, the results coming from a very challenging measurement of a VHF low directive measured in a multi-probe hemispherical systems are shown in the following section.

II. Example of Multi-Probe Measurement at VHF

Anechoic chamber measurements at low frequencies, such as VHF, have some criticalities. In fact at this frequencies, due to the limited electrical size of the available test-ranges and the absorber performances, the chamber reflectivity could be not good enough resulting in measurement environments affected by unwanted echo signals.

The measurement results presented in this section are relevant to two models of a VHF antenna working at 162 MHz. The antennas have been designed and manufactured in the frame of an ESA activity [5] and are part of a 5 element array mounted on a satellite for SAT-AIS initiative [5]. A photo of a manufactured antenna is shown in Fig. 2. As can be seen it consists of flat crossed dipoles over a surface of artificial magnetic conductors (AMC). A slotted ground plane has also been designed in order to improve the front-to-back ratio. A similar antenna element with a solid ground plane has also been designed and measured. Both elements are very small (λ/4 x λ/4 x λ/50 @ 162MHz) resulting in a very low directive antenna.

Fig. 2. AIS antenna on a slotted ground plane.

The measurement of the SAT-AIS elements has been carried out at the automotive measurement facility sited in the Renault Technical Centre at Aubevoye, France (see Fig. 3). Data acquisition is performed according to a regular sampling of 3.21° with a truncated area of ±80° in elevation. The outstanding measurement speed derives from the use of the multi-probe technology (a complete measurement campaign comprising 21 frequencies can be performed in approx. 35 minutes).

The range is an hemispherical multi-probe near-field system [7]-[7]. Due to the strong truncation of the spherical scanning area, the pattern obtained with standard NF/FF algorithm is likely to be affected by truncation errors as documented in [8].

In order to overcome the issues related to the above mentioned chamber reflectivity and truncation errors the data acquired in the hemispherical multi-probe system have been post processed with the commercially available MVG Insight software [9], which implement the so called equivalent current approach (EQC) / Inverse Source Technique [10]. Based on the acquired NF data, the equivalent electric and magnetic currents are determined on an arbitrary shaped reconstruction surface conformal to the test object. From the equivalent currents the field on the full measured surface can be evaluated. This process mitigates the pattern error due to scan truncation [11] that otherwise would show as a ripple due to the zero padding of the NF data in the traditional NF/FF transformation. The applied reconstruction surface is conformal to the antenna and defined so that sources of unwanted scattered signals or echoes remain external. The stray signals are therefore filtered out by spatial filtering [12].

The measurements of both element models (solid and slotted ground plane) have been post-processed with Insight in order to highlight the differences between the two designs. The computed equivalent electric currents associated to solid (left) and slotted (right) ground plane elements are reported in Fig. 4. In both cases the equivalent current techniques has been applied considering a box of size (0.6x 0.6 x 0.1) m with a mesh step of λ/15 @ 162MHz as a reconstruction surface enclosing the radiator.

Fig. 5 shows the directivity comparison on the E-plane obtained with a Time Domain simulations [13] (blue color), direct NF/FF transformation (red color) and equivalent current expansion (green color) of the solid ground plane element. In such a plot, the shaded areas indicate the pattern portions that have been reconstructed. The E-plane directivity comparison for the slotted elements is instead shown in Fig. 6. The improvements obtained by the EQC expansion are appreciable in both cases. In fact, the FF ripple caused the by the truncation of the scanning area and stray signals present in the measurement environment are strongly attenuated by the data processing.

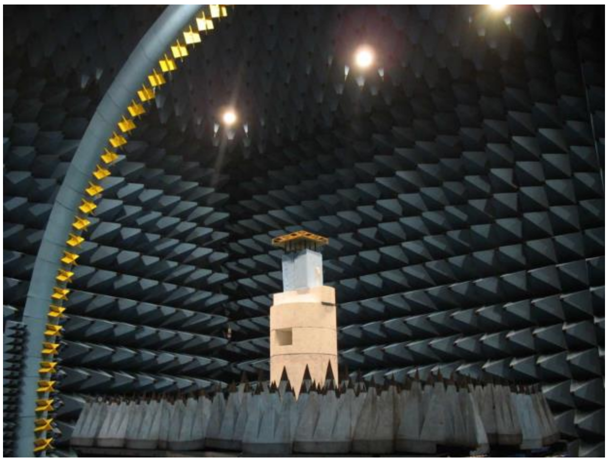

Fig. 3. AIS antenna in the embedded configuration during measurement in hemispherical range.

It is worth noting that the agreement between simulated and measured data obtained with Insight software is satisfactory even out of the reliable visible region of the measurement sphere, meaning that the equivalent current method has very good extrapolation capabilities. Due to this feature, it is possible to appreciate the improvements deriving from the design characteristics of the elements with slotted ground plane. In fact, as highlighted by the pattern cuts, the front-to-back ratio has been increased by approximately 5 dB.

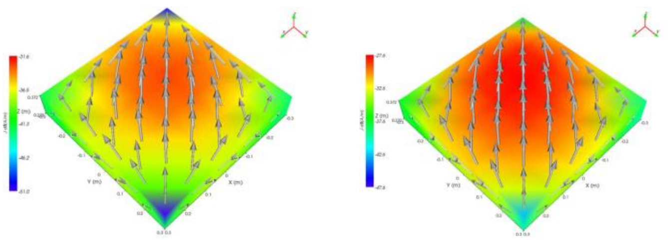

Fig. 4. Equivalent electric currents of the stand alone elements with solid (Left) and slotted (Right) ground plane.

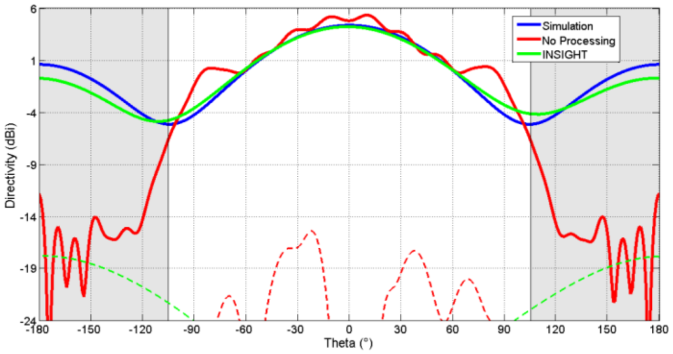

Fig 5. E-plane directivity pattern comparison of the stand alone solid ground plane element.

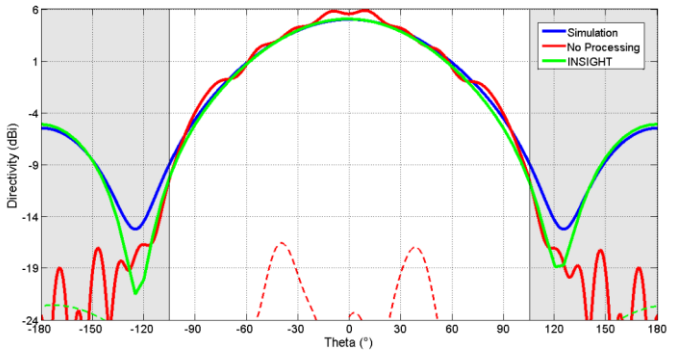

Fig 6. E-plane directivity pattern comparison of the stand alone slotted ground plane element.

III. Conclusions

In this paper the multi-probe system for antenna measurements have been presented as a valid and accurate alternative to single probe NF systems. The primarily purpose of a multi-probe system is to drastically reduce the testing time. In order to that, one mechanical axis is replaced by an array of electronically scanned probes.

In order to shown the capabilities of the multi-probe systems, a challenging measurement of two models of a VHF low directive antenna performed in the automotive (hemispherical) multi-probe Renault range have been presented. In order to overcome the issue related to the truncation error and limited chamber reflectivity at such low frequencies, the measured data has been post-processed with the MVG Insight software. The processed pattern results have shown a good improvement with respect to pattern obtained with the standard NF/FF transform. Indeed, it has been shown that even such challenging measurements at VHF can be performed combining multi-probe systems and advanced post-processing of the measured data.

References

[1] J.E.Hansen, "Spherical Near-Field Antenna Measurements", IEE Electromagnetic waves series 26, Peter Peregrinus Ltd.

[2] IEEE Reccomended Practice for Near-Field Antenna Measurements, IEEE Std, 1720-2012

[3] L.J. Foged, A. Scannavini, "Efficient testing of wireless devices from 800MHz to 18GHz, Radio Engineering Magazine, Vol 18, No 4, December 2009.

[4] Jean-charles Bolomey, Fred E. Gardiol, "Engineering Applications of the Modultaed Scattering Technique" Arthech House antenna and propagation library.

[5] A. Di Cintio, G. Della Pietra, A. Caliumi, G. Duchini,L. J. Foged, A, Giacomini, A. Potenza, L. M. Tancioni, N. Fonseca, "The AISMAN project: An Minutarized antenna array", 34th ESA Antenna Workshop, ESA/ESTEC Nordwijk NL, October 2012;

[6] P. Noren, Ph. Garreau, L. J. Foged, "State of the art spherical near-field antenna test systems for full vehicle testing", 6th European Conference on Antennas and Propagation, EuCAP 2012, March 2012, Prague, Czech Republic;

[7] http://www.satimo.com/sites/www.satimo.com/files/Product%20sheet_SG3000F_2010.pdf

[8] E. Martini, S. Maci, L. J. Foged, "Spherical Near Field Measurements with Truncated Scan Area", 5th European Conference on Antennas and Propagation, EuCAP 2011, Rome, Italy, 11-15 April 2011;

[9] http://www.satimo.com/software/insight

[10] L.J. Foged, L. Scialacqua, F. Saccardi, J. L. Araque Quijano, M. Sabbadini, G. Vecchi,"Equivalent Current Approach as an Advanced Field Interpolation Technique", IEEE International Symposium on Antennas and Propagation, APS, July 2012, Chicago, USA;

[11] L.J. Foged, L. Scialacqua, F. Saccardi, F. Mioc,J. L. Araque Quijano, E. Martini, S. Maci, M. Sabbadini,G. Vecchi, "Comparative Investigation of Methods to Reduce Truncation Errors in Partial Spherical Near-Field Antenna Measurements", EuCAP 2012, Prague, Czech Republic;

[12] L. J. Foged, L. Scialacqua, F. Mioc, F. Saccardi, P. O. Iversen, L. Shmidov, R. Braun, J. L. Araque Quijano, G. Vecchi, "Echo Suppression by Spatial Filtering Techniques in Advanced Planar and Spherical NF antenna Measurements", 34th Annual Symposium of the Antenna Measurement Techniques Association, AMTA, October 2012, Seattle, Washington, USA;

[13] www.cst.com