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Comparison of Antenna Measurement Results in Disturbed Environment using a VHF Spherical Near Field System

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Abstract—This paper presents parts of investigations done in a VHF spherical Near-Field system in order to propose appropriate measurement procedure. First is briefly presented the mono-probe near field system and measurement challenges due to low frequencies. Then is presented the Antenna Under Test (AUT), the antenna pattern comparison approach and the measurement configurations. Finally, several measurement results using two scans configurations are compared to reference simulation result in order to find the most appropriate way of measurement suited to the measurement facility for the large wavelength considered.

I. INTRODUCTION

Recent needs for monitoring and tracking in low VHF range below 100 MHz imply the use of specific antenna measurement facilities to characterize either the antenna alone or the antenna mounted on a supporting structure which can be heavy and bulky. Conventional outdoor far-field antenna measurement ranges used at UHF frequency bands and above become poorly effective down in VHF frequency band due to ground effects and electromagnetic pollution. Other implementations such as indoor far-field or compact range are not suitable at these very large wavelengths. The indoor Near-Field approach shows benefits in terms of compactness. However this approach involves issues due to high levels of reflectivity of the anechoic chamber and system components at these frequencies. Studies and characterizations of each component effect have been performed [1] and post processing techniques have been used and compared previously [2] to assess the system performances.

The proposed paper focuses on measurement configurations to properly characterize a very narrowband antenna taken as a reference. Considering the very narrow operational bandwidth the time filtering cannot be applied without removing critical antenna information. Thus this paper aims to propose an appropriate way to perform measurements dealing with the present reflections. By comparing the measurement results coming from two scan configurations to the simulation ones, is found a proper way to measure the

considered reference antenna in the considered CNES Near-Field system. Statistical approach is used to compare pattern results difference and a way to qualify the pattern results symmetry is proposed.

II. CNES VHF NEAR-FIELD FACILITY

The measurement used is the single probe spherical near field measurement system located in the chamber of the CNES in Toulouse France. This facility is dedicated to perform antenna measurement from 80 MHz to 200 GHz [3]. The chamber is shared by a compact range measurement system and a single probe near-field system. Above 400 MHz the compact range configuration is used. Below 400 MHz the near-field configuration is used. Nevertheless classical foam pyramidal absorbers are poorly efficient below 200 MHz. Therefore ripples due to reflections coming from the compact range reflector and from the chamber walls are present. In order to extend the operational measurement bandwidth down 100 MHz a new wide band and dual polarized VHF probe has been designed and manufactured [2] (*cf.* Figure 1). All the measurement results presented in this paper have been done by using this new probe.



Figure 1 Photograph of the dual polarized probe in the CNES VHF Near-Field system

III. DETAILS OF INVESTIGATIONS

A. Antenna Under Test

The Antenna Under Test (AUT) used for these investigations is a crossed double dipole mounted on a ground plane and working around 140 MHz in a narrow bandwidth. The AUT is considered as a reference antenna i.e with a well-known far-field pattern and a confident simulation model. The both dipoles are fed with equal amplitude signals with 90 degree phase difference. The expected symmetric far-field pattern covers a half sphere: $\varphi \in [0; 360^\circ]$ and $\theta \in [0; 90^\circ]$.

B. Antenna Pattern Comparison Approach

The strategy to compare measured patterns in the far-field region follows is the one used in [4] within the EU Antenna Centre of Excellence. Two far-field antenna patterns are compared using the weighted logarithmic difference to de-emphasize the noise and the large spikes. The weighted function W_{log} is composed by the $W_{n,3}$ noise function and the pattern weighting function W_p ($\beta = 0.3$) [4]. Thus the weighted logarithmic difference between two patterns $f_1(\theta, \varphi)$ and $f_2(\theta, \varphi)$ can be expressed by:

$$\Delta_{w,log}(\theta, \varphi) = W_{log} \Delta_{log}(\theta, \varphi) \quad (1)$$

With

$$\Delta_{log}(\theta, \varphi) = 20 \log_{10} f_1(\theta, \varphi) - 20 \log_{10} f_2(\theta, \varphi) \quad (2)$$

Each measurement result are compared to the simulated pattern (obtained by using FEKO EM simulation software) taken as reference. Two classical figures of merits are used to quantify the difference between both antenna patterns namely the mean value and the standard deviation (STD). Results are reported in section IV.B.

C. Measurement Configurations

Considering the fixed near field probe (*cf.* Figure 2) and its location inside the anechoic chamber, the AUT is moving around two axes (phi and theta) to perform the full sphere scan. As shown in Figure 2 the near field system is not located on a chamber axis of symmetry. Consequently the AUT could see different perturbations along the full sphere scan. Thus we considered and compared two ways of scanning the full sphere [5]:

- The "180 Phi" scan : $\theta \in [-180; 180]^\circ$ and $\varphi \in [0; 180]^\circ$
- The "360 Phi" scan : $\theta \in [0; 180]^\circ$ and $\varphi \in [0; 360]^\circ$

The "180 Phi" and "360 Phi" areas "seen" by the AUT are illustrated in the Figure 2 and Figure 3 respectively. Due to the theta excursion the "360 Phi" scan is expected to show more symmetric results than the "180 Phi" scan. Indeed in this last case perturbations coming from the CATR reflector are strongly different to the ones coming from the opposite wall. The amount of the perturbation should not be necessary lower but their effects are expected to be more homogeneous on the whole measurement sphere by using the "360 Phi" scan.

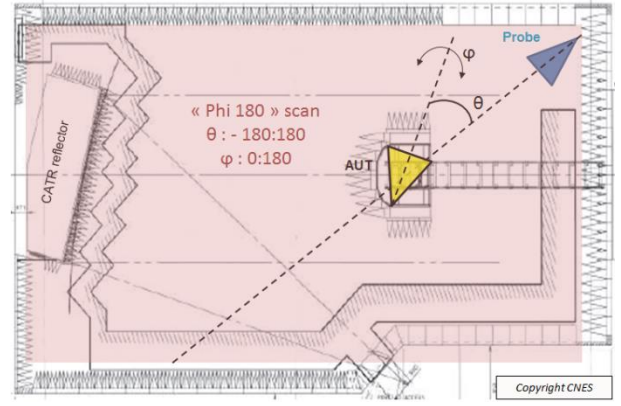


Figure 2 Illustration of the area seen by the AUT in the "180 phi" scan configuration – top view

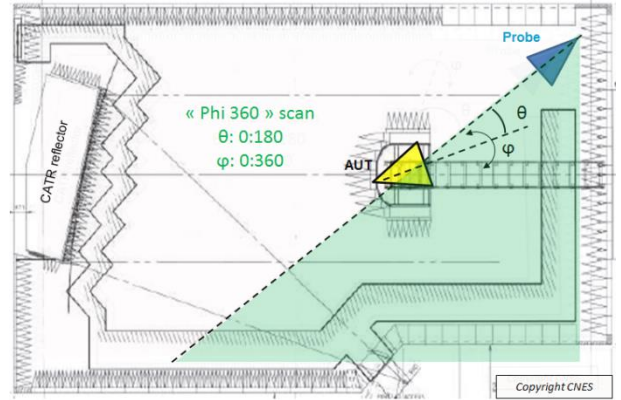
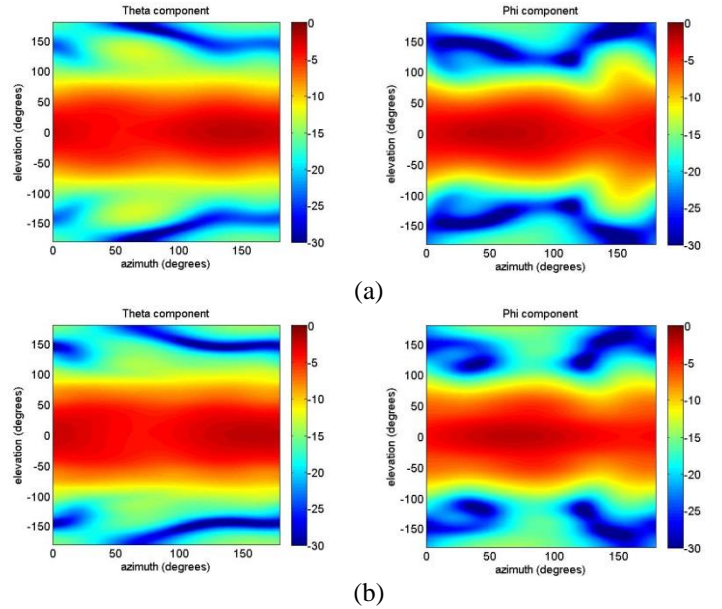


Figure 3 Illustration of the area seen by the AUT in the "360 phi" scan configuration – top view

IV. RESULTS COMPARISON

A. 2D and cuts patterns qualitative results



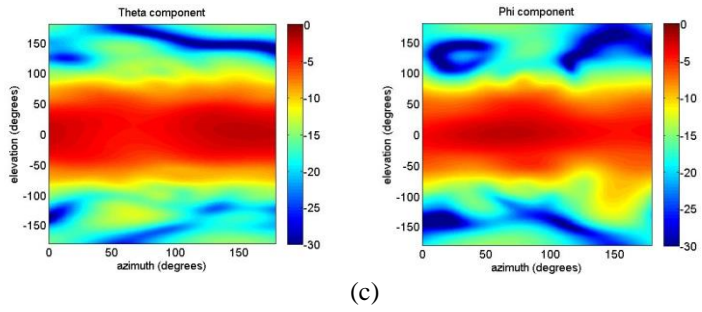


Figure 4 Examples of results around 140 MHz - Elevation vs. azimuth plots – Theta (left) and Phi (right) normalized patterns
 (a) Feko simulation - (b) CNES “360 Phi” measurement
 (c) CNES “180 Phi” measurement

Figure 4 shows the 2D patterns results obtained through simulation and both measurement configurations. Both components of the field are plotted (in dB with 0 dB for max value). We observe at this stage a better agreement between the “360 Phi” scan and the simulation results. The “180 Phi” shows a globally good behavior but seems to be more impacted by perturbations. Moreover an asymmetry can be observed on the “180 Phi” results. These first observations are confirmed by plotting several pattern cuts shown in

Figure 5. At high patterns levels a good agreement is obtained between the three results. Differences can be observed for lower levels on some cuts.

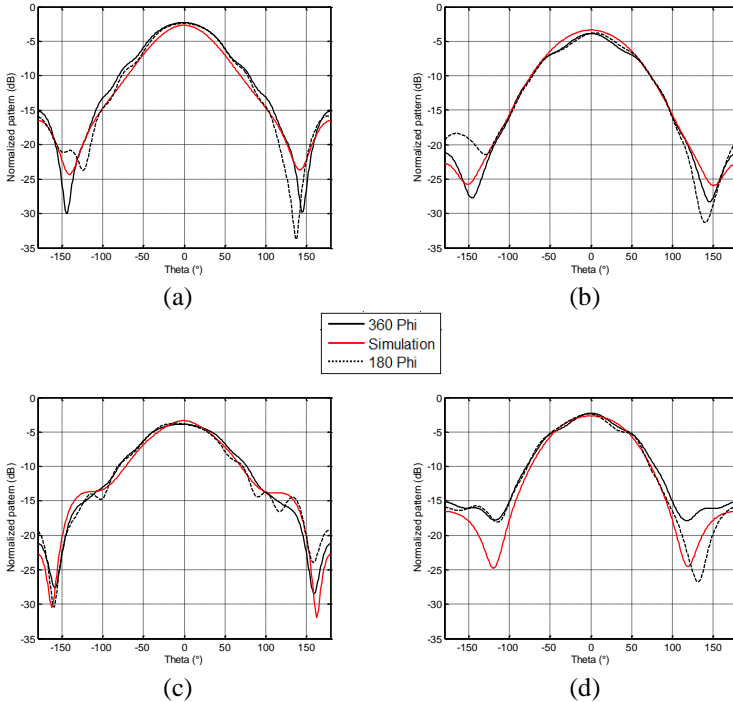


Figure 5 Comparison of radiation pattern cuts @ 140 MHz
 Cut Phi 0° - (a) Theta component - (b) Phi component
 Cut Phi 90° - (c) Theta component - (d) Phi component

B. Statistical data to quantify differences

Pattern comparison approach briefly described before is applied on the two scan configurations. Differences are computed on the whole patterns cuts ($\theta \leq 180^\circ$) between each scan configuration and simulation. Table 1 and

Table 2 synthetize the statistical values obtained for the “360 Phi” and “180 Phi” scan respectively. Both field components and four cuts are considered. Mean and STD values are computed and reported for each case.

TABLE 1 STATISTICAL FIGURES OF MERITS FOR THE WEIGHTED DIFFERENCE BETWEEN “360 PHI” SCAN AND SIMULATION

Cuts	ETheta component		EPhi component	
	Mean (dB)	STD (dB)	Mean (dB)	STD (dB)
Phi 0	0.38	0.82	-0.30	0.48
Phi 45	0.01	0.78	-0.01	1.47
Phi 90	0.03	0.70	0.93	0.88
Phi 135	0.31	1.27	-1.10	1.63

TABLE 2 STATISTICAL FIGURES OF MERITS FOR THE WEIGHTED DIFFERENCE BETWEEN “180 PHI” SCAN AND SIMULATION

Cuts	ETheta component		EPhi component	
	Mean (dB)	STD (dB)	Mean (dB)	STD (dB)
Phi 0	0.03	1.07	-0.10	1.14
Phi 45	-0.01	0.59	0.68	1.18
Phi 90	-0.01	0.88	0.36	1.07
Phi 135	0.21	1.41	-0.02	1.67

Looking on STD results the “180 Phi” scan shows differences slightly larger than the “360 Phi” scan. Mean values are even better for the “180 Phi” scan. Thus the preliminary qualitative observations about pattern asymmetry are not confirmed by this statistical approach. This is due to the use of STD and means values on the whole patterns. Consequently is proposed hereafter a small observation approach of the pattern symmetry disparity.

C. Pattern symmetry disparity

In order to add an information about the expected pattern symmetry, we proposed here a simple way to appreciate it. On Figure 6 is plotted an example of weighted logarithmic difference for the both scan configurations. We can clearly see that this difference is more symmetrical along the pattern for the “360 Phi” scan.

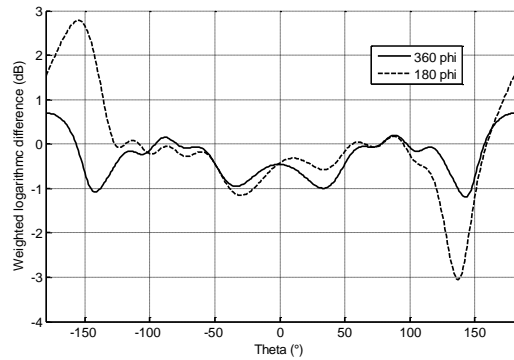


Figure 6 Weigthed logarithmic difference for the “360 Phi” and “180 Phi” scans – Cut Phi 0° - Phi Component

To appreciate the symmetry disparity of the weighted difference, a second logarithmic difference is computed between the first one and itself “theta flipped”. This simple approach is illustrated on Figure 7 for a cut of the “360 Phi” scan results where the red curve shows the symmetry disparity in dB on the whole cut *i.e.* the difference between the weighted difference on the considered cut and this same difference flipped in theta.

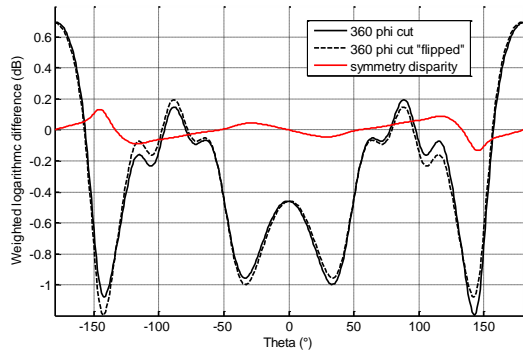


Figure 7 Weigthed logarithmic difference for the “360 Phi” and symmetry disparity – Cut Phi 0° - Phi Component

On Figure 8 are reported the symmetry disparity for the two scan configurations. Four Phi cuts (0° / 45° / 90° / 135°) for the Phi component are considered. An important gap between the two scan configurations is observed for all the considered cuts. The “360 Phi” scan results appear much more symmetric than the ones obtained by the “180 Phi” scan. This qualitative observation in addition with the statistical values obtained shows the benefit to perform the full sphere scan using the “360 Phi” scan configuration in the Near-Field CNES system.

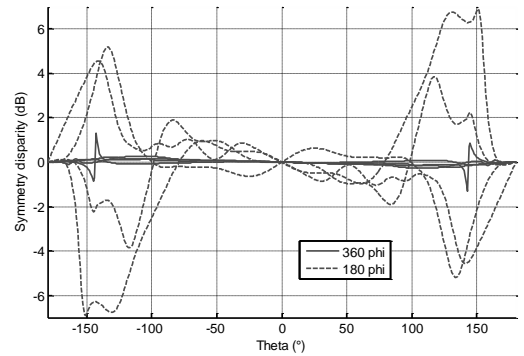


Figure 8 Symmetry disparity the “360 Phi” and “180 Phi” scans – Cut Phi 0°/45°/90°/135° - Phi Component

V. CONCLUSION AND PROSPECTS

This paper proposes an appropriate way to perform measurements of a narrowband antenna dealing with the reflections present in the Near-Field system used. By comparing the measurement results coming from two scan configurations to the simulation ones, a proper way to measure the considered reference antenna in the CNES Near-Field system is found. Statistical approach is used to compare pattern results difference and an additional way to qualify the pattern results symmetry is proposed to choose the best measurement configuration. Additional global error budget of the system could be provided in the presentation.

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