Truncation Study for Design of a Large Spherical Near-field Antenna Test System

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***Abstract*—A truncation study is presented to assess the impact of theta truncation in a spherical near-field antenna test system. The study is relevant for antennas with broad beams in the plane of truncation and where antenna weight prevents alternate mounting options, while facility space limitations necessitate truncation.**

Keywords—antenna testing; spherical near-field; near-field truncation; measurement simulation

I. Introduction

In many automotive and aeronautical applications it is often convenient to use spherical near-field (SNF) antenna test systems for antenna characterization. However, due to space limitations and antenna mounting restrictions it is often not possible to measure a full spherical surface and the impact of truncation determines feasibility of this type of measurement approach. In this paper we report results on an investigation into the sensitivity of the SNF measurement process to truncation in θ as it relates to a low frequency array antenna. This work was conducted in support of a new indoor antenna measurement facility and it illustrates how SNF simulation can be used in the facility design process. We present measurement geometry, simulation results and conclusions in what follows.

II. Measurement Geometry

The antenna under test (AUT) in question is roughly 36" (0.9 m) tall and 24' (7.3 m) wide (coordinate system depicted in

Fig. 1) and is operational at roughly 400 MHz. The proposed test system consists of a movable gantry scanner that rotates the AUT in ϕ and moves the probe in θ, where the latter may be restricted to ± 120° with 0° at zenith. A cross-section of the system is shown below in Fig. 2. In this diagram we show the theta angle limitation of 118° (approximated as 120° here).

The AUT principally radiates in the horizontal plane or where θ = 90°. It is known that the AUT has a 3 dB beam width of 20° in the vertical plane and much smaller in the horizontal plane. The results presented here are based on a numerical simulation [1 -3] and the AUT is modeled by as an array of linear dipoles as depicted in

Fig. 1 with the probe radial distance set to 3.8m.

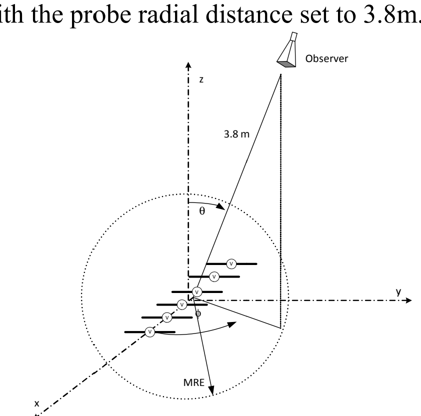

Fig. 1: Geometry of simulation #1. A linear array of 16 x 0.5λ dipoles is considered. The dipoles are horizontally arrayed along the x-axis, spaced 0.34λ apart and phased to allow for end-fire radiation. The total length of the array is roughly 3 m.

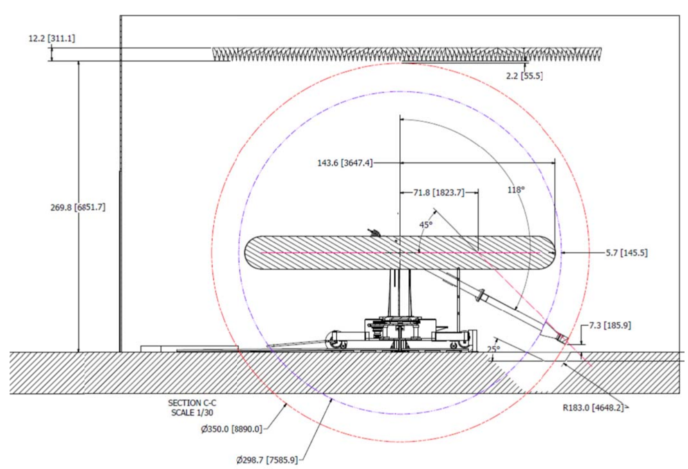

Fig. 2: Cross-section of the proposed facility, showing the theta angle limitation of 118°.

A single simulated dipole array source is considered here since this array generates the desired elevation plane beam width. The beam width in the azimuth plane will be controlled by the total number of end-fire arrays, but since truncation in this plane is not of concern, these additional arrays are not considered in this simulation. For this array, a far-field elevation plane 10 dB beam width of roughly 40° is noted.

III. Simulation Results

The following three simulation cases were considered:

#	AUT Type	θ Span Considered	Probe distance considered [m]	10 dB BW in Vertical plane
1	16 Dipole array	360° vs 240°	3.8	40°
2	16 Dipole array	360° vs 250°	3.8	40°
3	16 Dipole array	360° vs 260°	3.8	40°

Comparison of the near-field distributions (for one polarization component) for Case #1 for the full sphere and truncated sphere cases are shown below.

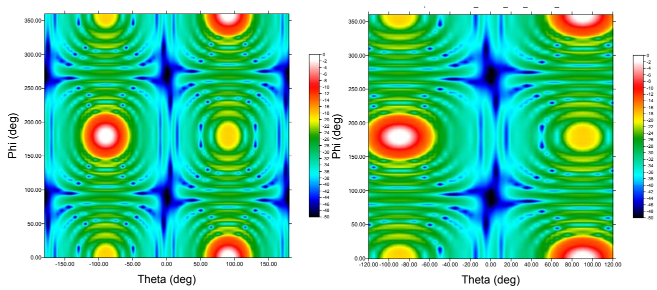

Fig. 3: Near-field amplitude distribution for one polarization component shown at a probe radial distance of 3.8 m for the full and truncated spheres for Case #1.

Transforming these near-field data sets to the far-field produces the results shown below. Radiation patterns for the θ = 90° and ϕ = 0° planes are shown in Fig. 4 (red is reference and blue is truncated). The impact of the truncation in the elevation plane is evident.

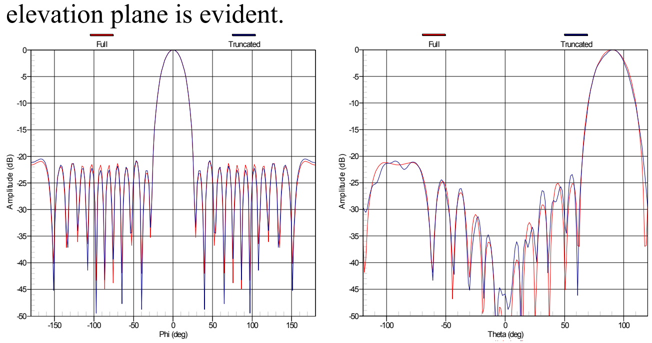

Fig. 4: Far-field amplitude pattern cuts for principal polarization component shown for the full and truncated spheres for Case#1 for the azimuth & elevation planes (θ = 90° left and ϕ = 0° right).

In the data presented above the truncation impact is significant in the elevation plane (plane of truncation) and this is the direct result of the near-field probe spanning 240° (therefore only 30° below the horizon). Proceeding to extend the scan range in theta by an additional 5° and 10° below the horizon reduces the impact of this truncation, as expected.

In Fig. 5 below we show far-field results with the full sphere reference case shown in red. Overlaid in blue are the far-field results derived from the truncated data and in purple the difference (error) level. Case #1 (120° lower θ angle) is shown on the left and Case #3 (130° lower θ angle) on the right. The results clearly show that the θ plane level of near-field truncation is critical in the success of measuring the AUT back lobe and side lobe levels. We see that the impact of truncation in the elevation plane for a θ scan range of ± 120° is as high as -25 dB in the main beam region of the AUT. Increasing the scan range to ± 130° reduces this number to -34 dB. We see that the impact of truncation in the back lobe for a θ scan range of ± 120 °is as high as -34 dB and less than -40 dB when the scan range is ± 130°. We also see that the first lower elevation side lobe (110°) cannot be measured with any degree of confidence for any of the truncated cases.

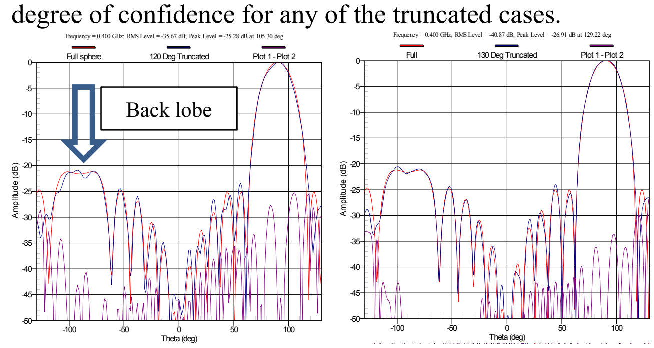

Fig. 5: Far-field amplitude elevation pattern cuts and error levels for principal polarization component shown for the ± 120 ° truncated sphere (Case #1) on left and ± 130 ° (Case #3) on right.

IV. Conclusions

The simulation results presented here assess the impact of truncation due to limited motion of the SNF probe in the θ direction. The results show minimal impact on radiation patterns in the horizontal (azimuthal) plane but significant impact on the vertical (elevation) plane patterns. It is seen that fairly small angular span increases help to reduce truncation effects significantly.

References

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