THE IMPACT OF ALIGNMENT ERRORS ON CYLINDRICAL NEAR-FIELD ANTENNA MEASUREMENTS

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Abstract

This paper addresses the sensitivity of the cylindrical near-field technique to some of the critical alignment parameters. Measured data is presented to demonstrate the effect of errors in the radial distance parameter and probe alignment errors. Far-field measurements taken on a planar near-field range are used as reference. The results presented here form the first qualitative data demonstrating the impact of alignment errors on a cylindrical near-field measurement. A preliminary conclusion is that the radial distance accuracy requirement may not be as crucial as was stated in the past. This paper also shows how the NSI data acquisition system allows one to conduct such parametric studies in an automated way.

Keywords: Cylindrical near-field, Measurement errors, Near-field scanners.

1. Introduction

Of the commonly used near-field scanning techniques, the cylindrical technique [1] has probably received the least investigative attention over the years. This paper addresses the sensitivity of the cylindrical near-field technique to some of the critical alignment parameters.

Measured data is presented to demonstrate the effect of errors in the radial distance parameter (i.e. knowing the azimuth axis to probe distance) and the effect of probe axis alignment on the far-field data. Regular sum type radiation patterns as well as difference patterns are presented.

The results form a good base for understanding the necessity of accurate alignment of cylindrical near-field scanners, for the parameters considered. More importantly, it also serves to quantify the tolerance required for the radial distance parameter. The data also provides valuable insight into the impact of probe correction on cylindrical near-field data since this process is not as intuitive as for the planar near-field case [2].

It is also shown how the NSI data acquisition system allows one to introduce alignment errors in a controlled fashion to conduct these parametric studies.

2. Alignment Parameters

A typical dual axis cylindrical acquisition scheme is depicted in Figure 1. In this configuration there is a vertical axis of rotation (indicated by z_0 in Figure 2) and a vertical axis of probe motion parallel to this axis. During the data acquisition the probe is moved parallel to the z_0 axis and the AUT is rotated around this axis so that data points can be acquired on a regular grid of (ϕ_0, c'_0). Variable ϕ_0 is the azimuth angle of rotation of the AUT and c'_0 is the linear distance of the probe above the AUT coordinate system. The separation distance between the probe coordinate system origin (shown as the probe tip) and the axis of rotation is denoted by x'_0 in Figure 2 and is referred to here as the radial distance parameter. This distance has to be specified for the cylindrical near-field transformation algorithm and its accuracy is dependent on the actual measurement process used during system calibration and also the coordinate system origin of the probe being used. (Note that when one is using measured probe patterns, this point will be defined by the coordinate system origin that was used during the probe calibration. When computed probe patterns are used, this point is defined by the far-field coordinate system origin used during the computation.) The latter is not always known for a given probe, and this fact therefore contributes to the uncertainty associated with this parameter. In what follows data is shown where known error values were introduced in the radial distance parameter, to study the far-field radiation pattern sensitivity to this.

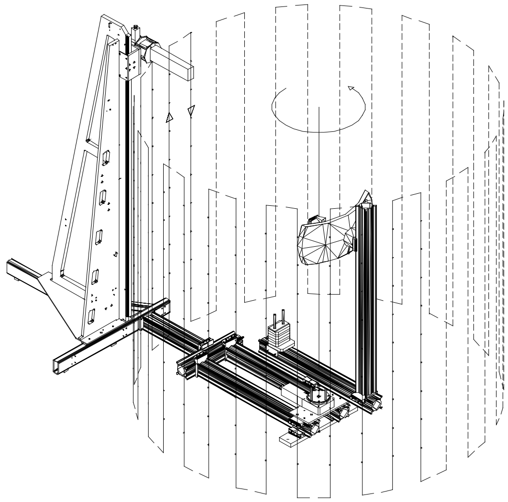

Figure 1: Typical cylindrical near-field data acquisition system.

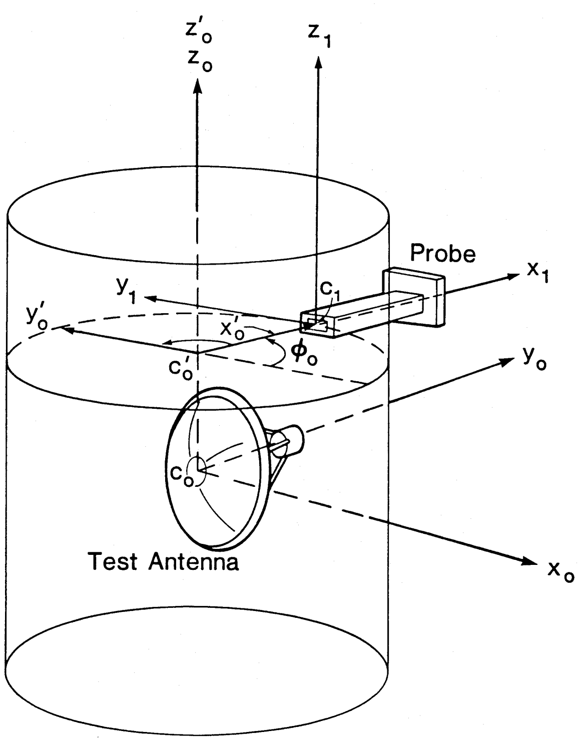

Figure 2: Cylindrical near-field coordinate system.

In addition to the radial distance parameter, the alignment of the probe itself within the cylindrical near-field system is of significance. Ideally the probe axis x_1 must be orthogonal to the axis of rotation z_0 and also intersect this axis. Further, the probe axis z_1 must be parallel to the axis z_0. From planar near-field theory it is well known that poor probe alignment translates directly to a point for point far-field pattern error [3, 4], where the error is proportional to the probe pattern variation due to the misalignment. In order to study the impact of this probe alignment on radiation pattern accuracy in the cylindrical near-field case, the effect of probe correction on the far-field data is investigated and comparative data is presented in the following section. Probe uncorrected data is compared to probe corrected results and the observed variation provides a direct indication of the impact of potential probe misalignment.

3. Measured Data

For the radial distance parameter test the system configuration as shown in Figure 3 was used. Here an AUT is shown mounted on a rotary positioner, mounted on an automated linear slide which allows variation of the radial distance parameter. The X-band AUT with sum and difference patterns was first measured using a planar scanning configuration for reference purposes and then using a cylindrical scanning configuration with scan size of 100° rotation (0.5 deg step size) and 2m vertical probe motion (16.5mm step size).

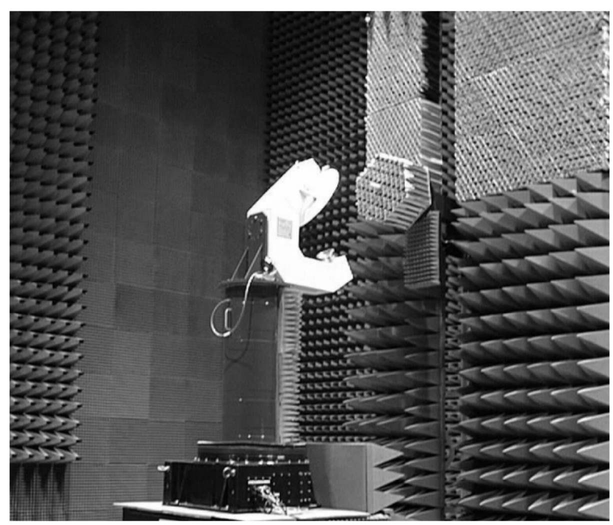

Figure 3: Cylindrical near-field measurement test configuration.

The probe to AUT axis of rotation distance was set to 1.1m. For the cylindrical parametric study test the AUT linear slide was set at radial distance offsets of 0, -0.2λ, -0.4λ, …, -1.6λ and this data acquisition was automated using the NSI software beam table capability as shown in Figure 4. Note that the column with heading “AUT switch” refers to three AUT ports, a sum and two difference ports. The right most column refers to the AUT linear slide, where the 0 position corresponds to an AUT to probe distance of 1.1m.

Beam	Dwell	AUT switch	Frequency	Y axis	Az axis	Pol axis	AUT Z
10	0.000000 mSec	0	9 GHz	Y axis	Az axis	Dual-pol	-0.99967
11	0.000000 mSec	1	9 GHz	Y axis	Az axis	Dual-pol	-0.99967
12	0.000000 mSec	2	9 GHz	Y axis	Az axis	Dual-pol	-0.99967
13	0.000000 mSec	0	9 GHz	Y axis	Az axis	Dual-pol	-0.79989
14	0.000000 mSec	1	9 GHz	Y axis	Az axis	Dual-pol	-0.79989
15	0.000000 mSec	2	9 GHz	Y axis	Az axis	Dual-pol	-0.79989
16	0.000000 mSec	0	9 GHz	Y axis	Az axis	Dual-pol	-0.60010
17	0.000000 mSec	1	9 GHz	Y axis	Az axis	Dual-pol	-0.60010
18	0.000000 mSec	2	9 GHz	Y axis	Az axis	Dual-pol	-0.60010
19	0.000000 mSec	0	9 GHz	Y axis	Az axis	Dual-pol	-0.40032
20	0.000000 mSec	1	9 GHz	Y axis	Az axis	Dual-pol	-0.40032
21	0.000000 mSec	2	9 GHz	Y axis	Az axis	Dual-pol	-0.40032
22	0.000000 mSec	0	9 GHz	Y axis	Az axis	Dual-pol	-0.19978
23	0.000000 mSec	1	9 GHz	Y axis	Az axis	Dual-pol	-0.19978
24	0.000000 mSec	2	9 GHz	Y axis	Az axis	Dual-pol	-0.19978
25	0.000000 mSec	0	9 GHz	Y axis	Az axis	Dual-pol	0 wvlng
26	0.000000 mSec	1	9 GHz	Y axis	Az axis	Dual-pol	0 wvlng
27	0.000000 mSec	2	9 GHz	Y axis	Az axis	Dual-pol	0 wvlng

Figure 4: Beam table example showing the automated acquisition sequence.

acquisition for multiple AUT ports and AUT z-positions. For the multiple cylindrical near-field acquisitions with introduced radial distance parameter offsets as described above, the radiation pattern data is shown in Figures 5 & 6. Note that during processing, the radial distance parameter was kept fixed at 1.1m for all cases thus inducing an error in the processing since the radius was indeed changed. The relative insensitivity of the elevation pattern data on this parameter is evident.

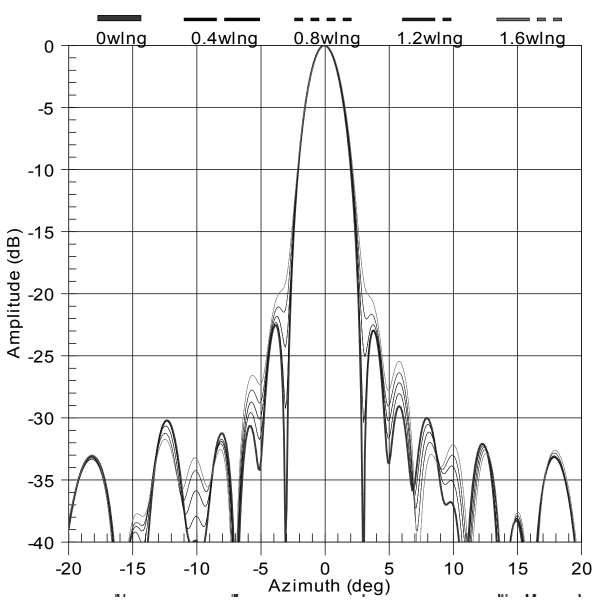

Figure 5: Azimuth radiation pattern data for multiple cylindrical near-field data sets with radial distance parameter offset values introduced.

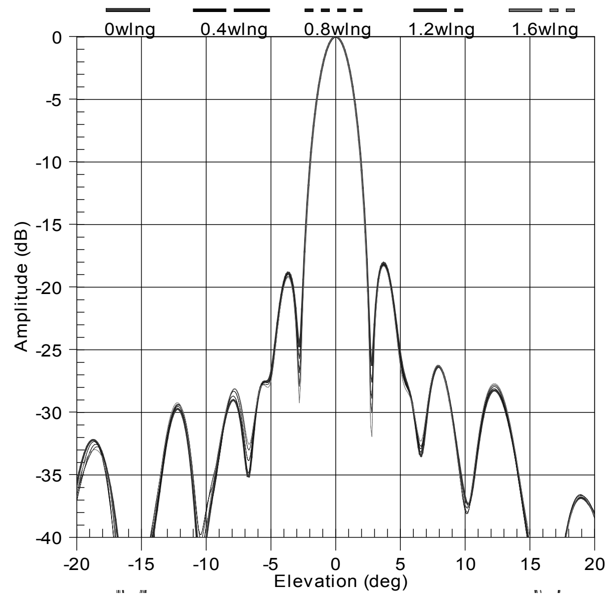

Figure 6: Elevation radiation pattern data for multiple cylindrical near-field data sets with radial distance parameter offset values introduced.

When comparing difference pattern data, similar behavior is noticed for azimuth and elevation patterns. However, for the azimuth pattern a significant difference pattern null position variation is noticed (0.05 deg) as seen in Figures 7 & 8.

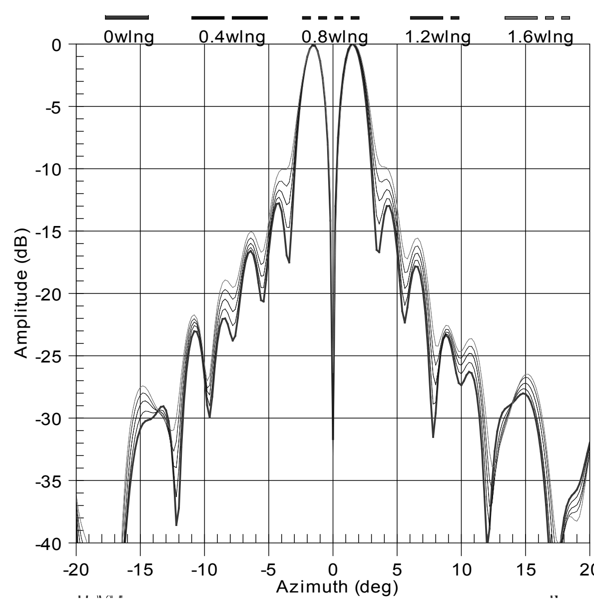

Figure 7: Azimuth difference patterns for radial distance errors.

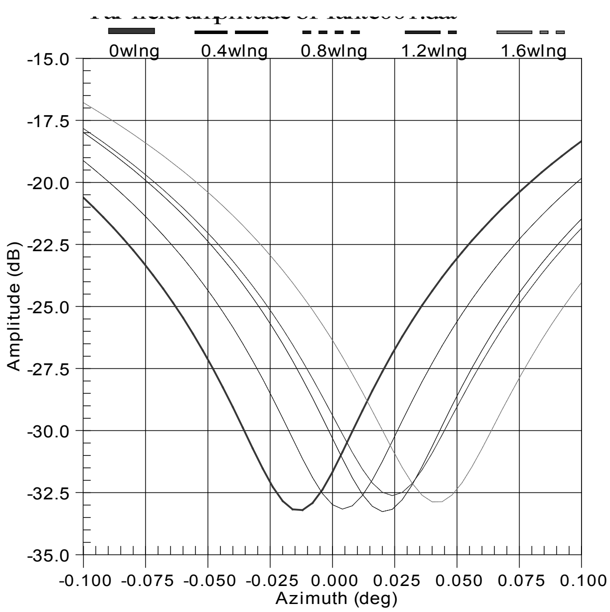

Figure 8: Enlarged section of null detail of Figure 7.

Figure 9 shows the co-polar azimuth radiation patterns for the AUT used for the probe correction studies. The patterns are shown for the probe corrected and the probe uncorrected cases. Also shown in Figure 9 are the probe pattern and the error curve (direct dB difference) between the two far-field patterns. Figure 10 shows the co-polar elevation patterns for the same AUT and these are again shown for the probe corrected and the probe uncorrected cases. Also shown in Figure 10 are the probe pattern and the error curve (direct dB difference) between the two far-field patterns.

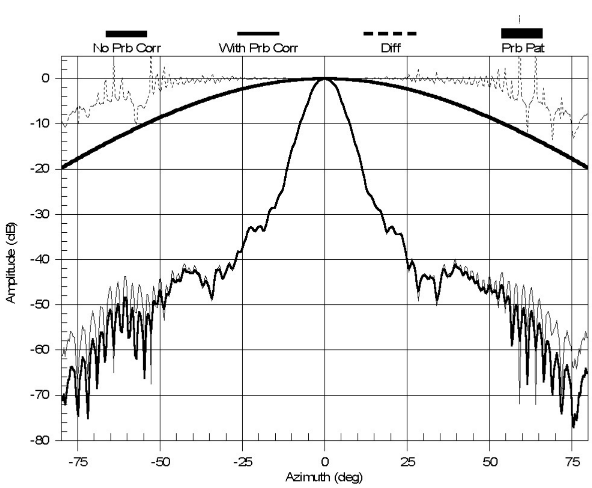

Figure 9: The impact of OEWG probe correction on the co-polar azimuth pattern cut.

The difference between the far-field patterns with and without probe correction can be used to estimate the error due to pattern and polarization uncertainties of the probe [3]. They show both the probe pattern and probe polarization effect. In the elevation cut, the pattern correction is basically the same as in the planar near-field case. In the azimuth plane it is a much smaller effect, since it is an average of the probe pattern over a range of azimuth angles for each calculated far-field angle. The polarization effect, shown by the deviations from the smooth pattern curves are much smaller than expected, and seem to occur only where the AUT cross-polar pattern becomes equal to or greater than the co-polar pattern.

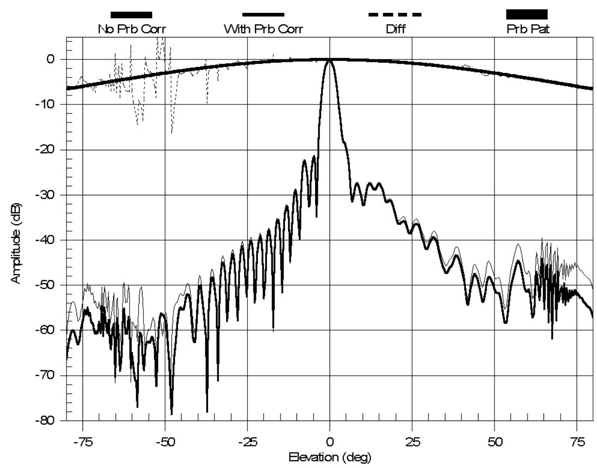

Figure 10: The impact of OEWG probe correction on the co-polar elevation pattern cut.

4. Conclusions

The data presented in this paper demonstrates the sensitivity of the cylindrical near-field measurement technique on the radial distance parameter. It is clear that the impact of this parameter is almost negligible on elevation pattern data and more significant for azimuth pattern data. Further, based on the data shown here, a preliminary conclusion is that the target accuracy for determining this radial distance parameter should be better than 0.1 λ, which is less stringent than what is commonly believed to be required. However, given the difference pattern null position variations noticed in azimuth patterns, further investigation is warranted.

The impact of probe correction on cylindrical near-field data has also been demonstrated. These results showed that probe correction in the elevation plane is similar to that for the planar near-field case (i.e. the probe pattern affects the far-field radiation pattern on a point for point basis). However, in the azimuth plane the effect of probe correction is a distributed one and single probe data point errors do not affect single far-field data points. This phenomenon thus appears to make the cylindrical near-field technique less sensitive for probe alignment errors in the horizontal plane.

5. References

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