2010 Conference on Precision Electromagnetic Measurements
June 13-18, 2010, Daejeon Convention Center, Daejeon, Korea

AMTA-3

COMPARISON OF NEAR-FIELD METHODS AT NIST

K. MacReynolds, M.H. Francis and D. Tamura
The National Institute of Standards and Technology
325 Broadway, Boulder, CO 80305

Abstract

A comparison of the planar, spherical and cylindrical near-field techniques was completed at the National Institute of Standards and Technology (NIST) for a Ku-band cassegrain reflector antenna. This paper discusses the measurement results for the near-to-far field measurements.

Introduction

The antenna metrology laboratory has three near-field ranges. Two of the ranges are used primarily for planar near-field measurements and one range is capable of both cylindrical and spherical near-field measurements. We were interested to see how well the measurements results compared between the different ranges and techniques.

Description of the Intracomparison

Four near-field measurements were completed on three antenna ranges for this comparison. It was of interest to see how the different near-field techniques compare as well as how the measurements would compare on the various ranges at our facility. Two of the measurements were planar near-field, with one set done on a small planar range (2 m X 2 m) and one set on a large planar range (4 m X 4 m). Cylindrical and spherical near-field measurements were made on another range capable of performing both types of measurements. A Ku-band dual-port linearly polarized Cassegrain reflector antenna was used as the antenna-under-test (AUT). It has a 61 cm aperture and a nominal gain of 36 dBi. A dual-port linearly polarized probe was the source antenna. The probe was previously characterized for on-axis gain, polarization and patterns to allow for probe correction of the various near-field measurement techniques. Figure 1 shows the AUT and probe. This paper will discuss the measurement results and uncertainties for the four measurements specifically targeting the co-polarization on-axis gain and centerline pattern data [1-5]. The scope of this paper does not allow for discussion of the different measurement techniques.

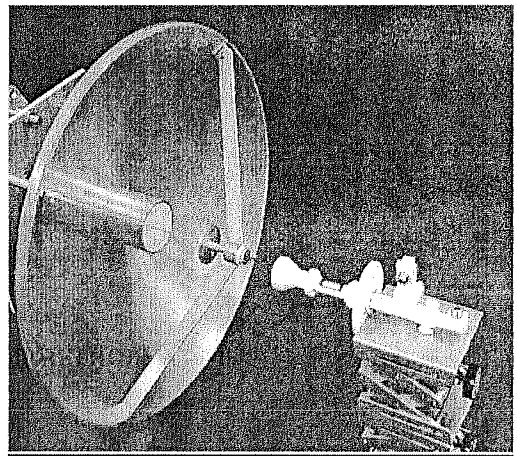

Figure 1. Picture of the Cassegrain antenna and probe used for the measurements.

Planar near-field measurements

Both planar near-field ranges use box scanners with the scan plane defined by the x-y coordinate system. The AUT is centered and aligned to the scan plane at a fixed separation distance from the probe. The probe moves in equal steps in x and y over the plane in front of the AUT. Measurements on the large planar range were taken over a 1.98 m x 1.98 m scan plane with a separation distance between the AUT and probe of 22 cm. Data were taken in half wavelength ($\lambda/2$) spacing over the scan plane. The scan size on the small planar range was 1.5 m x 1.5 m scan plane with a separation distance between the antennas of 25 cm. Data on this range were taken with 0.4λ spacing. The parameters for both measurements should provide reliable far-field data out to an angle of about 50 ° [5].

Spherical Near-Field Measurements

The spherical range has a roll-over azimuth positioning system. The coordinate system is defined with the z-axis horizontal and nominally along the boresight of the antenna and either the x- or y-axis aligned with the major polarization axis of the antenna. In these measurements, the probe is fixed and the AUT moves to map out a sphere. The radius between the probe and the AUT defines the size of the sphere. Near-field data were taken at a radius of 1.5 m with data point spacing of 1° over the sphere.

Cylindrical Near-Field Measurements

The cylindrical measurements were taken following the spherical measurements and using the same range. In the cylindrical measurements, the probe moves in a vertical or y-direction with the AUT rotating in azimuth providing data on a cylinder. The radius remained the same with 1° in azimuth and $\lambda/2$ spacing in the y-direction.

Measurement Results

The on-axis gain value and uncertainty for each of the measurements are shown in Table 1.

Table 1. On-Axis Gain with Uncertainty			
	dBi		dBi
Small Planar	35.80 ± .30	Spherical	35.77 ± .27
Large Planar	35.62 ± .34	Cylindrical	35.32 ± .30

Figure 2 is a graph showing a centerline cut from each of the measurements for the co-polarization.
The on-axis gain agrees within the uncertainties for all the measurements. Figures 2 and 3 are graphs showing a centerline cut from each of the measurements for the co-polarization. All of the pattern data have been normalized to peak-of beam.

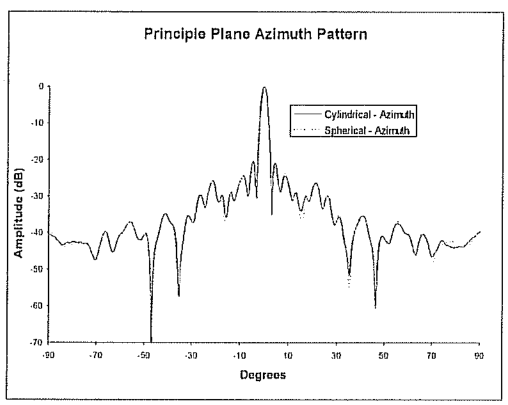

Figure 2. Centerline far-field pattern data for the spherical and cylindrical near-field measurements.

The spherical and cylindrical measurements show very good pattern agreement (to within the uncertainty of about 0.1 dB per dB below beam peak) over the entire ∀ 90°. The far-field pattern taken with the spherical near field technique is very symmetrical and that for the cylindrical technique is less so.

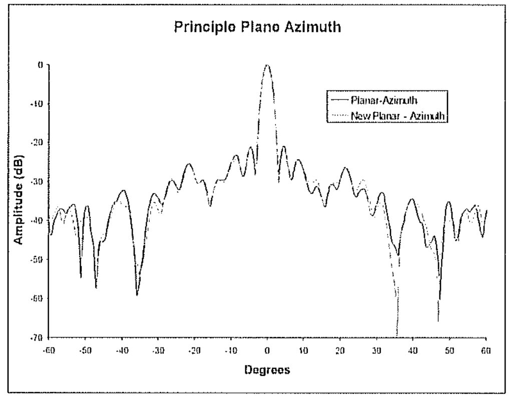

Figure 3. Centerline far-field pattern data for the small and large planar near-field measurements.

The two planar measurements show good agreement (to within the uncertainty of about 0.1 dB per dB below beam peak) only through the first couple of sidelobes.

We plan to provide a detailed uncertainty budget for each of the four measurements in the lab comparison and discuss in more depth the possible causes for any discrepancies in the far-field results.

References

[1] A.D. Yaghjian, "Antenna Measurements on a Cylindrical Surface: A Source Scattering-Matrix Approach," *National Bureau of Standards Technical Note 696,* Boulder, CO, June 1977.

[2] A. C. Newell, R. D. Ward, and E. J. McFarlane, "Gain and power parameter measurements using planar near-field technique," *IEEE Trans. Antennas Propagat.*, vol. AP-36, no. 6, pp. 792-803, June 1988.

[3] P. F. Wacker, "Non-Planar Near-Field Measurements: Spherical Scanning," *NBSIR 75-809*, June 1975

[4] A.C. Newell, "Planar Near-Field Antenna Measurements," *NIST Short Course Notes*, Boulder, CO, March 1994.

[5] A.C. Newell, "Error Analysis Techniques for Planar Near-Field Measurements," *IEEE Trans. Antennas Propagat.*, vol. AP-36, no. 6, pp. 754-768, June 1988.