CYLINDRICAL NEAR-FIELD MEASUREMENT OF L-BAND ANTENNAS

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ABSTRACT

Andrew Corporation, founded in 1937 and headquartered in Orland Park, Illinois, has evolved into a worldwide supplier of communication products and systems. To develop a superior, high performance line of base station products for a very competitive marketplace, several new antenna measurement systems and upgrades to existing facilities were implemented. This engineering project developed an indoor test range facility incorporating design tool advantages from among Andrew Corporation's other antenna test facilities. This paper presents a 22-foot vertical by 5-foot diameter cylindrical near-field measurement system designed by Nearfield Systems Incorporated of Carson, California. This system is capable of measuring frequencies ranging from 800 MHz to 4 GHz, omnidirectional and panel type base station antennas up to twelve feet tall having horizontal, vertical or slant (+/- 45 degree) polarizations. Far-field patterns, near-field data and even individual element amplitude and phases are graphically displayed.

Keywords: **Antenna Measurements, Design, Facility Descriptions, Near-Field, Cylindrical, and Data Acquisition.**

INTRODUCTION

Andrew Corporation, founded in 1937, based out of Orland Park, Illinois, has evolved into a worldwide supplier of communications products and systems. Andrew has a long tradition of technological innovation and market leadership in the fields of microwave, broadcast, satellite and wireless antennas and related products. Recently, Andrew has entered the highly competitive marketplace encompassing cellular, GSM, paging, PCN and local wireless loop base station antennas. The decision was made to capitalize on Andrew's extensive antenna expertise in the development of a superior, high performance line of base station products i.e. antennas with low VSWR, high levels of upper sidelobe suppression and null fill. To help meet these challenging design goals several new antenna measurement systems and upgrades to existing facilities have been implemented.

Figure 1 Cellular Base Station Antennas

Among Andrew Corp.'s many antenna test facilities are far-field ranges as long as 2,560 feet and as small as 55 feet tapered anechoic chambers. These were designed primarily for the testing of large parabolic reflector antennas down to single dipole elements, used in the design of terrestrial microwave systems and broadcast antennas, respectively. Research and development teams within Andrew also have developed extensive design tools including near-field scanning programs as well as a field probe device to measure the phase and amplitude variations of individual radiating elements. Of course, each of these design tools has its own advantage, i.e. maximum antenna size, range length, measurement speed, etc. The goal of this engineering project was to develop an indoor test range facility incorporating as many of these advantages as possible.

This paper presents a 22 ft. x 5 ft. diameter, cylindrical near-field measurement system designed by Nearfield Systems Inc. (NSI) of Carson California. This system is capable of measuring omndirectional and panel type base station antennas up to 12 feet tall, in the frequency range of 800 MHz to 4 GHz, and having horizontal, vertical or slant (+/- 45°) polarizations. The system can display far-field patterns, near-field data and even the individual amplitude and phases of each element. The system provides a user friendly software interface as well as a robust mechanical construction, capable of measuring and maintaining highly accurate and repeatable pattern measurements.

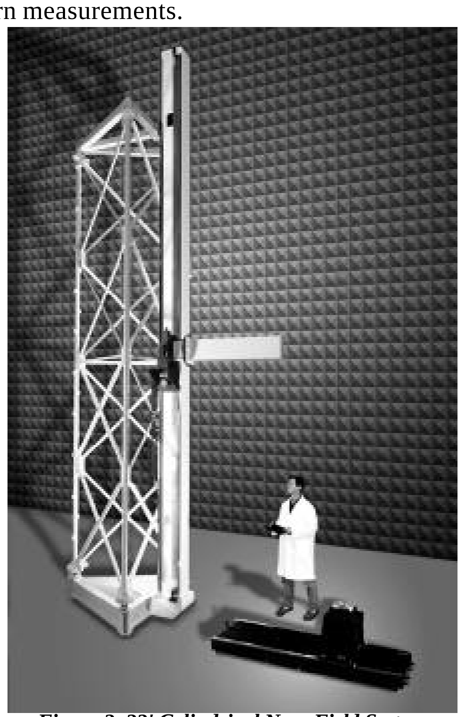

Figure 2 22' Cylindrical Near-Field System

2. Measurement System Description

The near-field antenna measurement system consists of an anechoic chamber, a cylindrical scanner and an antenna positioner (Figure 2). The installed system, shown in Figure 3, is located at Andrew's manufacturing facility in Addison, Illinois.

The anechoic chamber (Figure 3) is recessed in a pit to allow ample space for the vertically oriented antennas. The height of the building allowed twenty feet above floor level. Excavating a cavity for the system's base provided an additional six feet of chamber height. This arrangement also allows for easy placement of an antenna under test. Positioned at mid height within the chamber, large doors on the wall opposite from the scanning probe are accessible from a floor platform. The chamber sides are square, each twelve feet in length; so with twenty-four-inch absorber, form an eight-foot square test section that is twenty-two feet in height from the bottom to the top twelve-inch absorber tips.

Figure 3 Near-Field Test Chamber

The cylindrical scanner is located outside the chamber and views the AUT through a slot in the chamber wall. This arrangement minimized the size and expense of the anechoic chamber. Locating the scanner external to the chamber also facilitated its installation. Three points secure the scanner's base to the foundation of the pit. The tower attaches to the base with three adjustable devices used to plumb the probe motion in two vertical planes within a few arc-seconds. An open-ended waveguide probe, mounted to a carriage, moves on a column that connects at the bottom to the scanner base and at the top to the scanner tower. The vertical scan range is twenty-two feet and the probe rotates 360°. The tower weighs approximately 4,500 pounds.

The antenna positioner is located inside the chamber below a raised floor supporting the bottom absorber. A slot in the bottom absorber allows the positioner to adjust the AUT distance from the probe. The travel range is five feet for the azimuth stage providing 360° rotation capability. It weighs approximately 400 pounds.

This system is capable of cylindrical near-field measurements of broadbeam antennas with frequency ranges from 800 MHz to 4 GHz.

2.1 Electrical Validation Tests

To determine the correlation between the near- and far-field measurement facilities, three antennas shown in Figure 1 were chosen for pattern testing: 4-bay dipole array (45" tall), 6-bay dipole array (68" tall), and an 8-bay dipole array (92" tall). These samples represented different sizes of antennas with various electrical downtilt configurations within a cellular frequency range of 800 to 960 MHz.

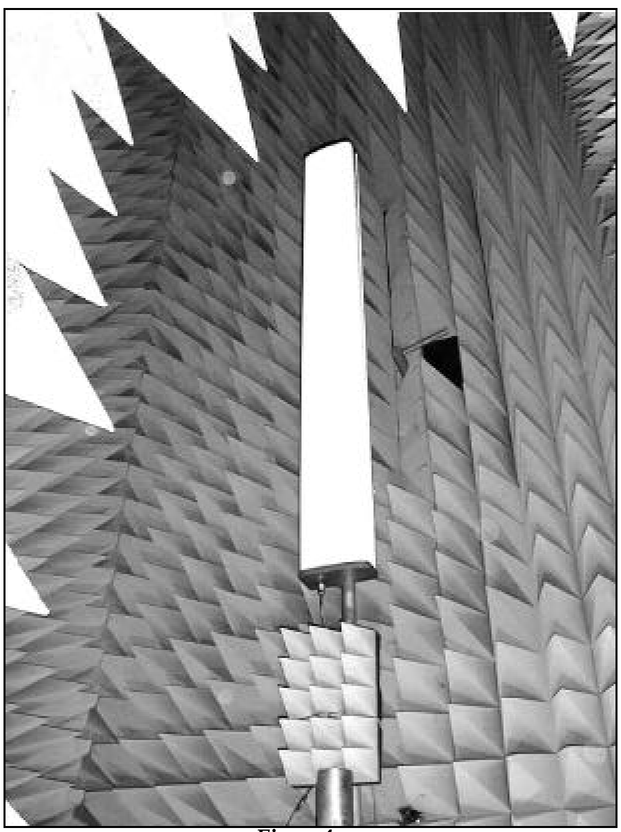

Figure 4
Vertical 92" 8-Bay Dipole

The antennas are vertically polarized, phased dipole arrays over the formed metal ground plane. Amplitude and phase tapers were adjusted in the designs to give different amounts of electrical downtilt, sidelobe suppression and null-fill. Amplitude taper alone was applied to the 4-bay antenna. The higher gain 6- and 8- bay antennas utilized both the phase and amplitude taper.

Near-field and far-field patterns were measured and compared (Figures 5 – 8). Various parameters were measured, including elevation beam peak, elevation 3 dB beamwidth, azimuth 3dB beamwidth, azimuth front-to-back ratio, first upper sidelobe level, first lower sidelobe level, and the first lower null depth. The far-field data was taken at Andrew's, 250-foot ground reflection range.

3. Summary

Extremely good correlation was obtained for the selected antennas at various frequency ranges within the 800 to 960 MHz range. Beam peak levels and front-to-back ratios tracked very closely. Half power beamwidths were within acceptable limits. The elevation beam peak varied by as much as 1° for the 8-bay antenna. It is thought that closer attention to the mechanical alignment process between the probe and test antenna will bring this within ½ degree as shown by the 4- and 6- bay patterns.

References

1. Slater, Dan, *Near-field Antenna Measurements*, Artech House, Norwood, MA 1991.

Comparison Chart – Near-field vs. Far-field

4 Bay Array Over Reflector, Frequency = 800 Mhz						
Pattern Data	Elevation beam Peak (deg)	Elevation 3 dB BW (deg)	Upper Peak (dB)	Lower Peak/null (dB)	Azimuth 3 dB BW (deg)	Azimuth F/B ratio (dB)
Near-field	1.04	19.75	-19	-18/-20	96	21
Far-field	0.75	19.43	-19	-19/-20	94	22

6 Bay Array Over Reflector, Frequency = 960 Mhz						
Patter Data	Elevation Beam Peak (deg)	Elevation 3 dB BW (deg)	Upper Peak (dB)	Lower Peak/null (dB)	Azimuth 3 dB BW (deg)	Azimuth F/B ratio (dB)
Near-field	-5.45	12	N/A	-16/-21	88.5	23
Far-field	-5.70	11.53	N/A	-14/-19	89.3	23

8 Bay Array Over Reflector, Frequency = 880 Mhz						
Pattern Data	Elevation Beam Peak (deg)	Elevation 3 dB BW (deg)	Upper Peak (dB)	Lower Peak/null (dB)	Azimuth 3 dB BW (deg)	Azimuth F/B ratio (dB)
Near-field	-3.82	9.25	-11.7	N/A	90.5	23
Far-field	-2.83	8.36	-11.1	N/A	91.4	23

Comparison Overlay Patterns of Near-Field and Far-Field Data

Near-Field ——
Far-Field **——**

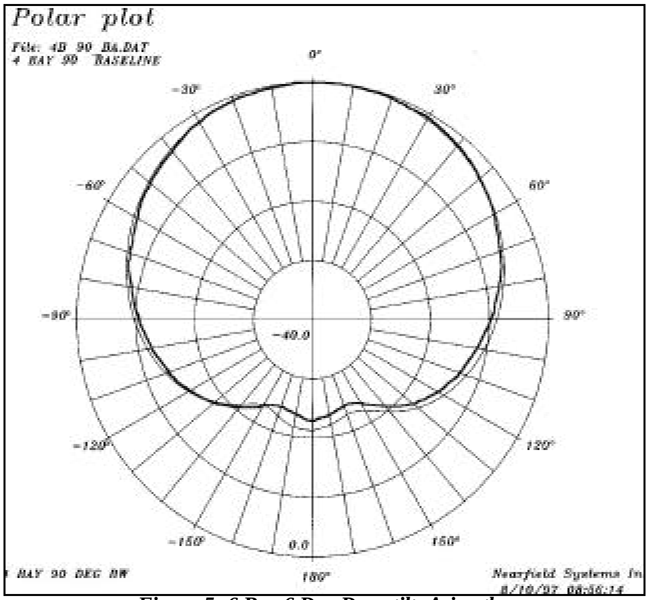

Figure 5 6 Bay 6 Deg Downtilt- Azimuth

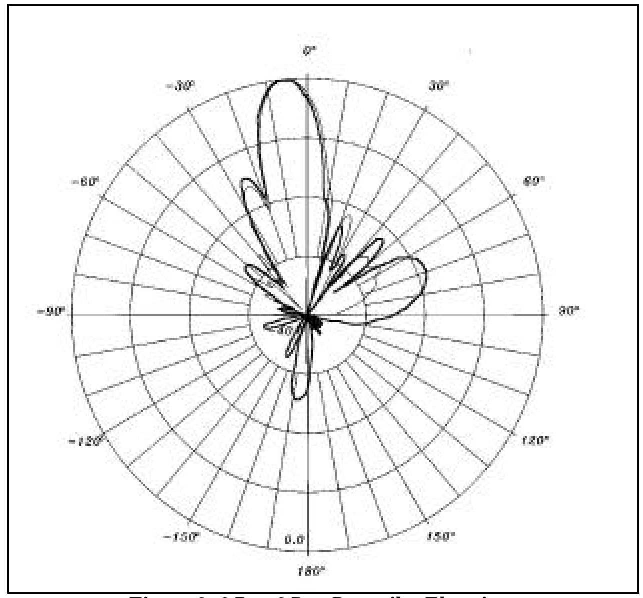

Figure 6 6 Bay 6 Deg Downtilt - Elevation

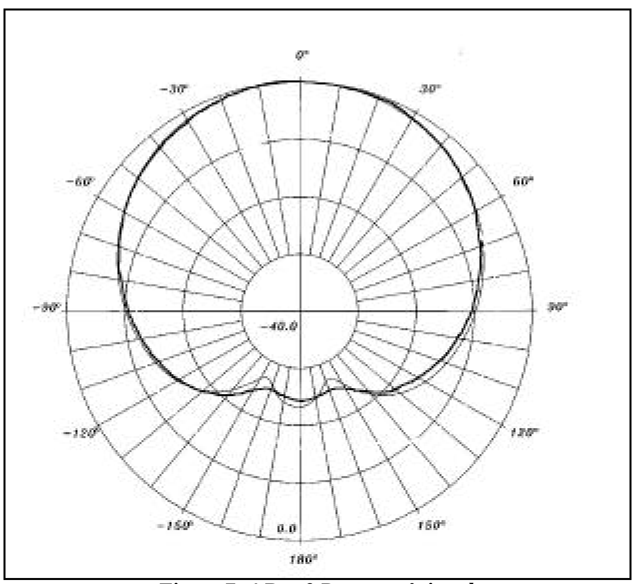

Figure 7 4 Bay 0 Degree - Azimuth

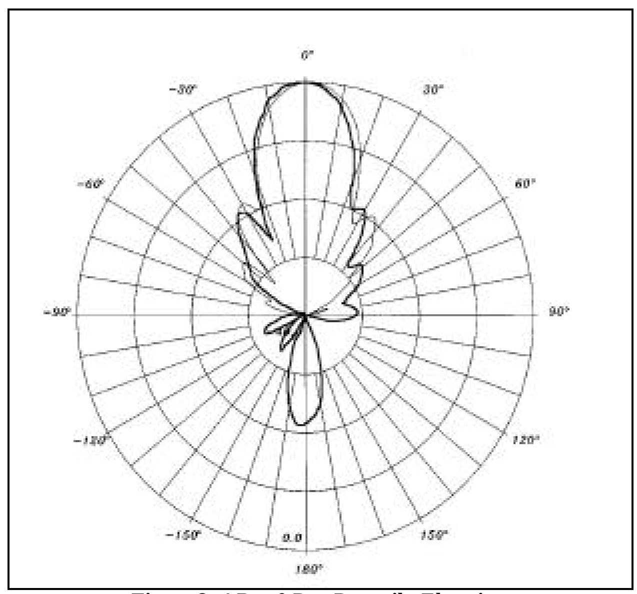

Figure 8 4 Bay 0 Deg Downtilt- Elevation