Array Antenna Pattern Measurement Techniques

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***Abstract*—Antenna patterns are measured using two independent methods and compared. Excellent agreement between far-field measurement and measurements from anechoic chamber and near-field techniques.**

***Index Terms*—Anechoic Chamber, Antenna Pattern Measurement, Far Field Measurement, Antenna Arrays**

I. Introduction

Measurement of antenna patterns on a far-field test range, in a near-field environment, or in an anechoic chamber has been studied and standardized [1]. The correlation between measurements made in the far-field and those made in an anechoic chamber is also an active field of study [2]. Independent radiation pattern measurements of two UHF broadcast antenna arrays are compared and discussed.

Two major areas of interest when specifying performance parameters for television transmitting antennas are elevation pattern and azimuth pattern [3]. For proper coverage, a great deal of time, money and effort are usually expended to determine not only the ideal azimuth and elevation patterns but also their relationship to available transmitter power configurations and limitations. The final radiation pattern of any antenna is determined by the amplitude and phase distribution over the antenna aperture [4]. The aperture effects can be divided into two separate and independent radiation characteristics: the azimuth pattern and the elevation pattern. The product of these two patterns gives the total radiation pattern for the antenna.

II. Azimuth Pattern Measurement

For UHF antennas, directional azimuth patterns are often chosen to optimize the coverage of the viewing area and to maximize the Effective Radiated Power (ERP) of the antenna by using the higher azimuth gains [5]. It is very important to eliminate all extraneous signals from the measurements or significant error can be introduced.

The appropriate conditions are accomplished by using an anechoic chamber (see Figure 1) for azimuth pattern testing. The anechoic chamber is designed with absorbing material that covers the walls, ceiling and floor to prevent any unwanted reflections during the measurement procedure [1]. The anechoic chamber is a controlled measurement environment. It aims to represent the free space condition of the design criteria because it minimizes reflections and, at the same time, allows direct measurement of the azimuth pattern. It is not subject to the dynamic environmental influences that affect measurements on a far-field test range, reflections from buildings, vegetation, seasonal changes, rain, snow or ice. This assures both very accurate measurement results and repeatability of the results at any time.

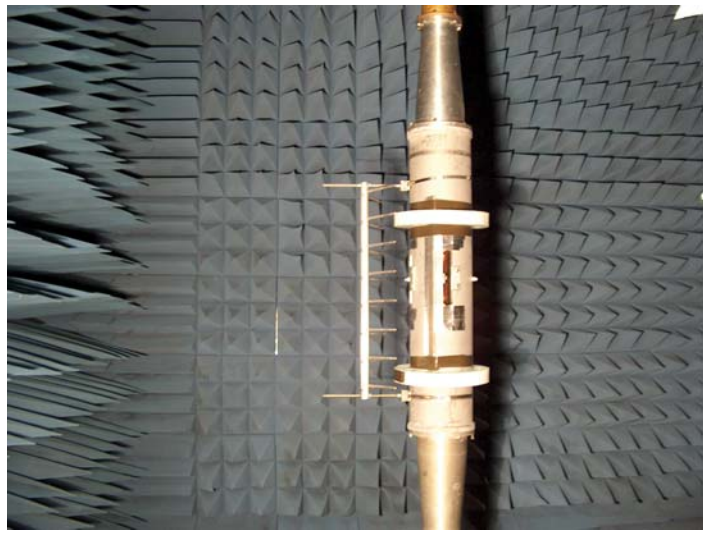

Figure 1: Anechoic Chamber (Courtesy ERI)

If the geometry of the antenna array is the same at any cross section, it is only necessary to measure a full-scale segment of the array to determine the azimuth pattern of the full antenna. The factorization of the antenna pattern into an element pattern and array factor allows model studies and other investigations to be carried out where only the azimuth pattern is of interest. In order to provide the most accurate measurements possible and to ensure that the antenna is in strict conformance with the design requirements, an anechoic chamber is employed for antenna model measurements and production testing of broadcast antenna azimuth patterns. A full-scale, one-bay model for two antenna arrays was measured in an anechoic chamber and compared with patterns measured on the full array on a far-field test range (Figures 2 and 3).

III. Elevation Pattern Measurement

To determine the elevation pattern of the antenna requires that the entire array be assembled and that the phase and amplitude distribution across the aperture be measured. Because reflections and extraneous signals can cause significant error in this measurement, ideally the antenna should be placed inside an anechoic chamber and the elevation pattern measured in the same manner as the azimuth pattern. However, the physical size and cost of such a structure prohibits this in the UHF band.

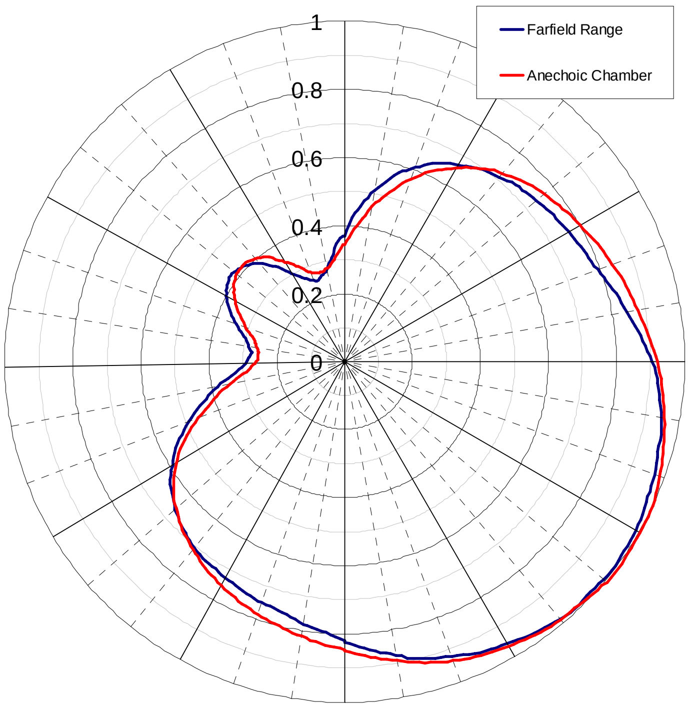

Figure 2: CH32 Azimuth Pattern Comparison

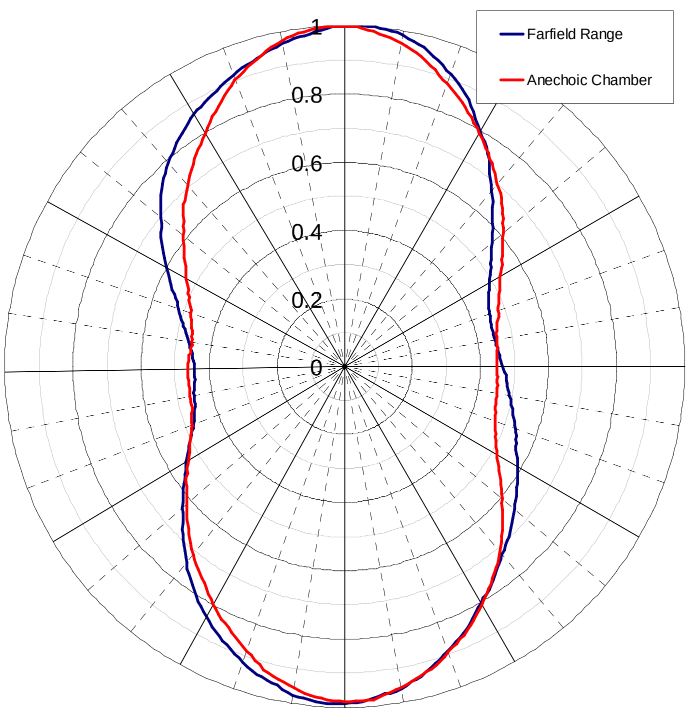

Figure 3: CH26 Azimuth Pattern Comparison

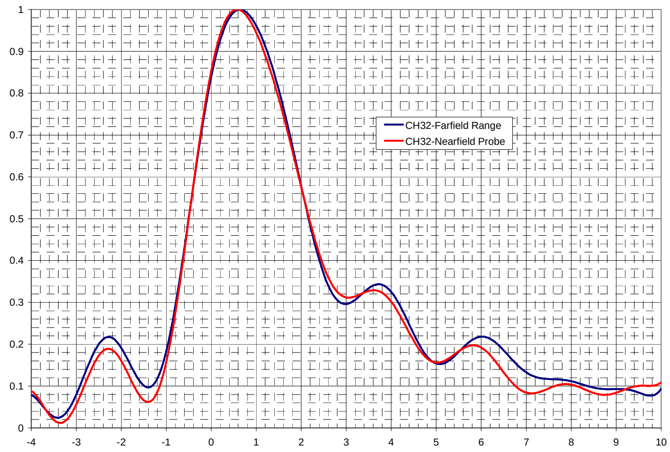

Figure 4: CH32 Elevation Pattern Comparison

An alternate method of measurement was developed to simulate the "free space" condition of the anechoic chamber. This near-field method uses an isolated probe to measure the slot excitation (amplitude and phase) of each slot in the array.

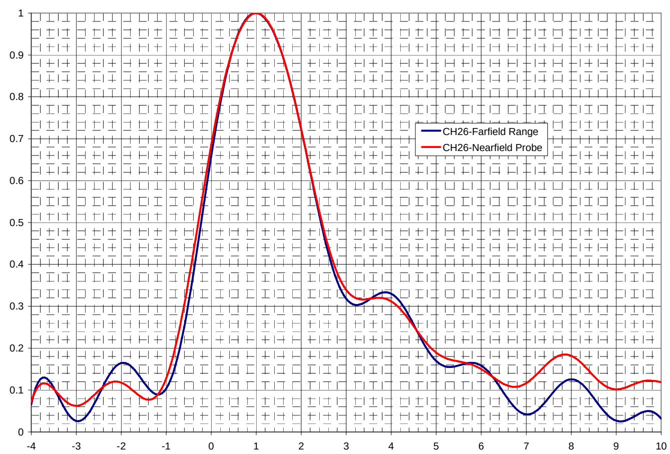

Figure 5: CH26 Elevation Pattern Comparison

With the measured data, α_i, β_i, and the known array geometry, d_i, the array factor may be computed by the following equation [4],

$$E(\theta) = \sum \alpha_i e^{j(kd_i \cos\theta + \beta_i)} \qquad (1),$$

where k is the propagation constant and θ is the elevation angle. The product of the array factor and the pattern of the one-bay element produce the elevation pattern The measured data and pattern are compared with the design data for conformance to design specifications.

There are two major advantages of this measurement technique. Because the measurements are made in the near-field, the effects of reflections and other unwanted signals are greatly reduced. Also, because the elevation pattern specifications are based on a particular phase and amplitude distribution across the aperture, a direct comparison between predicted and measured patterns and distributions is possible.

This greatly accelerates the test program by eliminating the need to determine if any variances are caused by interference in the measurements. Any adjustments that are necessary are immediately visible as well as what corrective action is required. Again, this technique is a measurement of the radiation pattern near-field method for improving accuracy when comparing to the design criteria.

The elevation patterns of two UHF arrays were measured using the near-field sampling method and are compared with the direct far-field measurements (Figures 4 and 5).

IV. Pattern Comparisons

To better understand the ability to accurately measure the radiation patterns of a broadcast transmitting antenna, a comparison with traditional far-field measurements is shown. Variations in the azimuth pattern are less than 1dB, and variations in the main beam region of the elevation pattern are also less than 1dB. The differences may be attributed to undesirable reflections in the far-field test environment. The pattern data from the near-field probe measurement (for the elevation pattern) and the anechoic chamber (for the azimuth pattern) show excellent correlation with far-field test range results.

References

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