Analysis of Antenna Null-fill and Broadcast Coverage

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***Abstract*—Antenna pattern characteristics of end-fed and center-fed arrays are discussed. End-fed arrays are found to have improved null-fill and coverage.**

***Index Terms*—Antenna Arrays, Antenna Patterns, Propagation Analysis**

I. INTRODUCTION

Antenna arrays for high-power broadcast applications have key differences in feed networks and pattern performance. High-power slot array antennas vary primarily between end-fed and center-fed arrays [1]. The power in an end-fed array is applied at one end and is delivered to each element in a manner that produces patterns with high side-lobes and high null-fill, characteristics that produce improved areas of coverage.

Pattern differences between end-fed and center-fed arrays are derived from fundamental principals, and the propagation is analyzed. In particular the role of increased null-fill, the amplitude of the pattern minima in the region near the main-lobe, in improving coverage.

II. ELEVATION PATTERN SYNTHESIS

The radiated fields of an antenna are related to the distribution of fields at the antenna aperture. For arrays of discrete elements, the aperture distribution is related to the fields at each element. Given the amplitude and phase of each radiating element, α_i, β_i respectively, and the known (linear) array geometry, d_i, the array factor may be computed by the following equation [2],

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

where k is the propagation constant and θ is the elevation angle. If the array consists of similar elements, the product of the array factor and the pattern of one element produce the elevation pattern. Note that the quantity computed by Equation (1) is a complex number, providing both amplitude and phase of the elevation pattern.

III. SIDE-LOBES AND NULL-FILL

The side-lobe structure of an antenna may be interpreted by considering the vector interference of the fields at the edges of the aperture. The side-lobes of an end-fed array are generally high and the respective nulls are heavily filled (Figure 3). This may be understood by the fact that the two edges of the aperture have very different amplitudes (Fig. 1a). When the two vectors interfere constructively (in-phase) the large sidelobe peaks occur, and when they interfere destructively the heavily filled nulls occur.

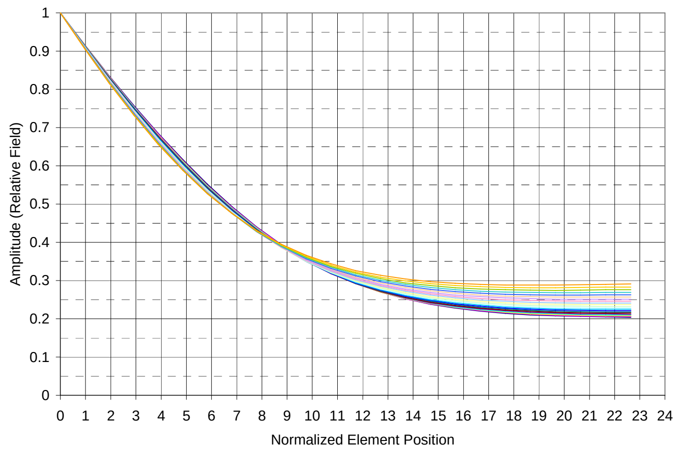

Figure 1a: Amplitude Aperture Distribution of End-Fed Array

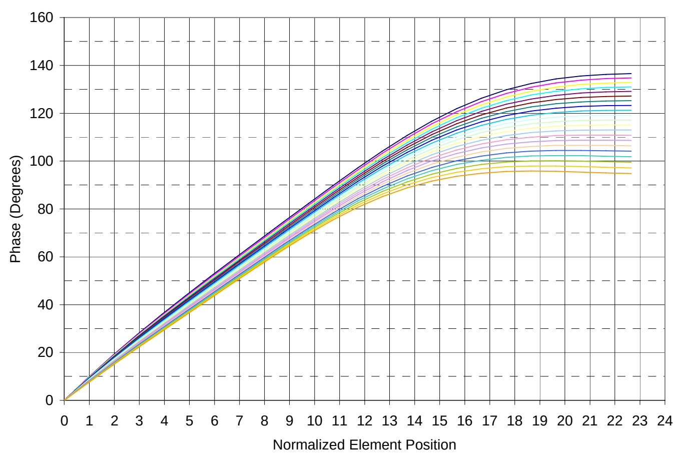

Figure 1b: Phase Aperture Distribution of End-Fed Array

Because the aperture distribution of the center-fed array, shown in Figure 2, has lower amplitudes at each end of the array, the magnitude of the side-lobes produced in the pattern (Figure 3) are lower than those produced in the end-fed case. The nulls are also lower because the amplitude of the fields is nearly equal at the ends of the center-fed array, adding destructively in the nulls.

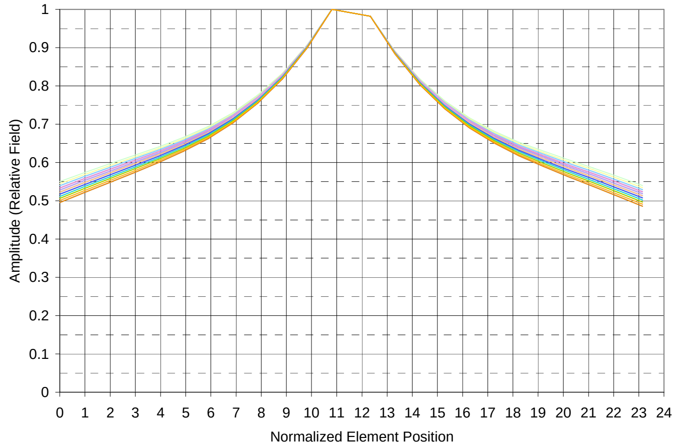

Figure 2a: Amplitude Aperture Distribution of Center-Fed Array

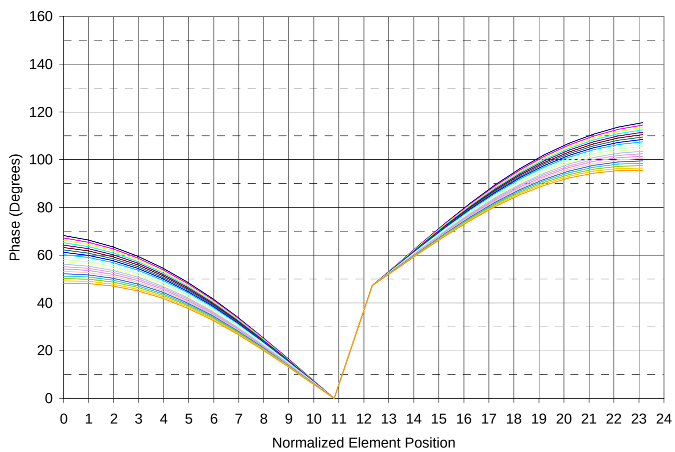

Figure 2b: Phase Aperture Distribution of Center-Fed Array

IV. SMOOTH EARTH PROPAGATION

Patterns from the two array types are shown in Figure 3. The end-fed array pattern has characteristic high side-lobes and high null-fill, and the center-fed array pattern has lower side-lobes and null-fill. Figure 4 shows the resulting signal at the surface of the earth with the antenna mounted atop a 1000ft. tower.

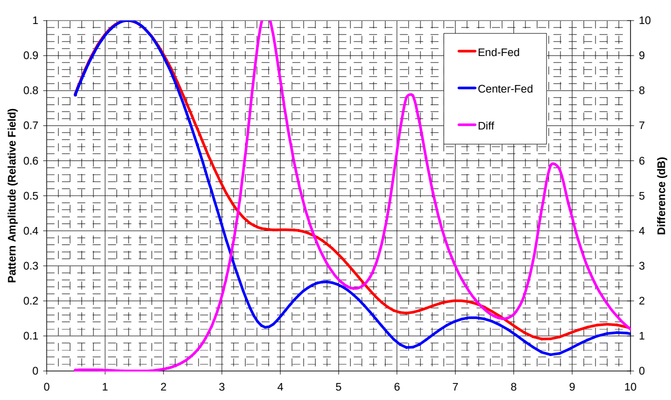

Figure 3: Array Patterns, 1.4 deg, Beam-tilt

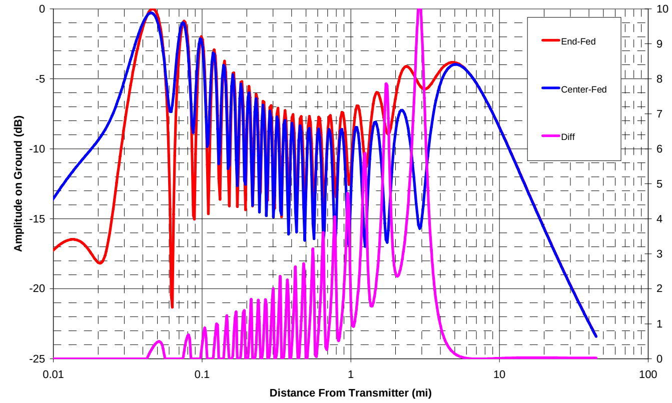

Figure 4: Relative Received Signal, 1.4 deg. Beam-tilt

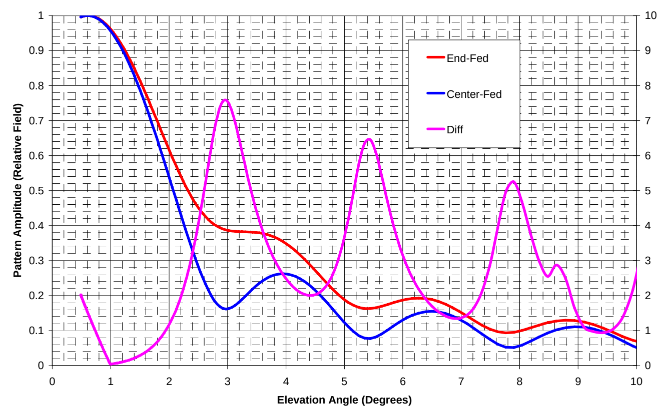

Figure 5: Array Patterns, 0.6 deg, Beam-tilt

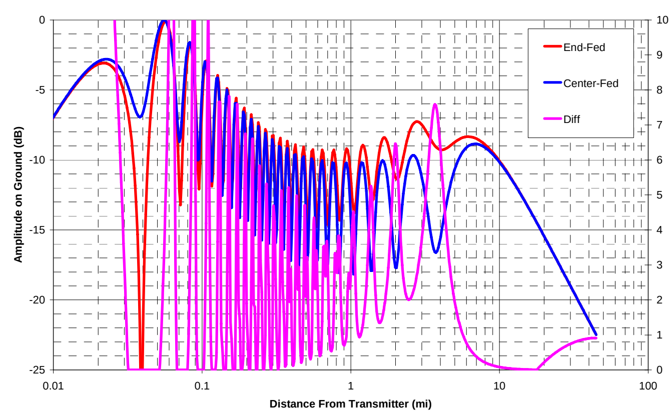

Figure 6: Relative Received Signal, 0.6 deg. Beam-tilt

Figures 5 and 6 show the results of an array with 0.6 degree beam-tilt, and Figures 3 and 4 are the results at 1.4 degree beam-tilt.

V. CONCLUSIONS

End-fed arrays for television broadcast applications produce patterns with higher side-lobes and higher null-fill than center-fed arrays. For the same ERP, the antenna patterns of the end-fed arrays have 10dB higher amplitudes in the side-lobe region, translating to 10dB improvements in coverage areas several miles from the tower. These coverage improvements are key in improving signal to noise ratios in urban propagation environments with interference and multi-path challenges [3].

REFERENCES

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[3] G.W. Collins, *Fundamentals of Digital Television Transmission,* John Wiley & Sons, Inc., New York, 2001.

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