Analysis of Smooth Patterns and Broadcast Coverage

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***Abstract*—Antenna pattern characteristics of side-lobe level and null-fill are compared. The application of smooth, null free patterns is discussed.**

***Index Terms*—Antenna Arrays, Array Patterns, Null-Fill.**

I. Introduction

One of the important considerations in the design of a television transmit antenna is the elevation (or vertical plane) radiation pattern. Along with its azimuth (or horizontal plane) radiation pattern, the elevation pattern determines the peak of maximum directivity the antenna can produce. In choosing an elevation pattern, there are many parameters to consider, such as gain, beamwidth, beamtilt, null-fill, and side lobe levels. Also, for a specific antenna type, the frequency sensitivity of these parameters should be investigated across the bandwidth of interest [1]. This article focuses on the areas of null-fill and side lobe levels and demonstrates the advantages of smooth elevation patterns used by ERI with respect to these two parameters.

II. Standard Elevation Patterns

A typical elevation pattern will exhibit side lobes both above and below its main radiation beam. For terrestrial television broadcast applications, it is the side lobe structure below the main beam that is of importance, since the radiation above the main beam is generally pointing off into space. The number of side lobes present varies with the number of radiating elements in the vertical array; that is, the higher the number of elements, the higher the number of side lobes [2].

A typical ERI UHF 28-gain elevation pattern is shown in Figure 1. The side lobe region is roughly between 3 and 10 degrees. Although these lobes continue down to 90 degrees (corresponding to the base of the tower on which the antenna is mounted), the first 10 degrees usually covers the entire viewing area. For example, a depression angle of about 10 degrees from atop a 1000 ft tower corresponds to a distance of about 1 mile from the base of the tower.

III. Propagation Effects

If an antenna with this pattern is assumed to be on a 1000 ft tower, a diagram of relative signal strength vs. distance from the tower can be plotted based on these parameters [3]. This is shown in Figure 2. It can be seen that the signal strength fluctuates about 5 dB within the first three miles from the tower. This region on the plot corresponds to the side lobe region on the pattern in Figure 1. Such a minimal range of fluctuation about a strong, mean signal (minimum city grade coverage for UHF is 80 dBu) is the product of sophisticated array design techniques. Many center-fed broadcast antennas exhibit more severe fluctuations in this region, due to deeper nulls between the side lobes in their vertical plane patterns (less null-fill).

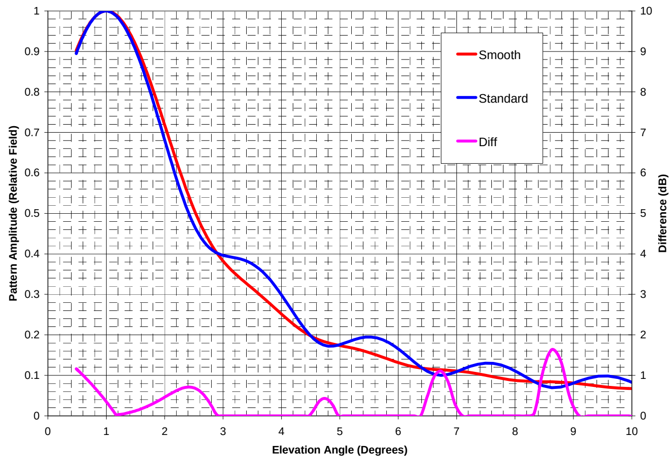

Figure 1: Standard and Smooth Elevation Patterns

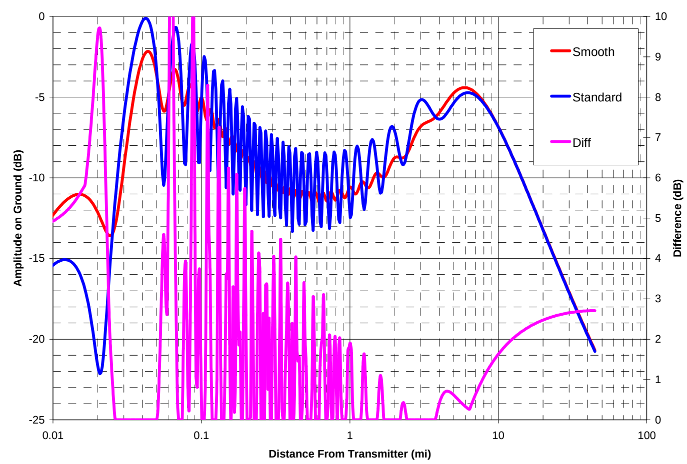

Figure 2: Relative Signal Strength on Smooth Earth

IV. Coverage Considerations

In many instances, this near-in region of a station's coverage area is of little importance, since there are no viewers within a few miles of the tower on which the antenna is mounted. In these situations, the standard pattern in Figure 1 produces excellent results. Looking again at the associated propagation plot in Figure 2, it can be seen that the signal strength beyond the 3-mile point tapers off very smoothly and consistently.

Conversely, certain transmitters are located completely within or immediately adjacent to their viewing areas and have viewers essentially right up to the antenna tower. An example of this might be an urban market in which the antenna tower is within or very near a residential area. Alternatively, antennas may be atop tall buildings in downtown areas. In these situations, two potential problems are of concern, both related to the side lobe structure in the antenna's elevation pattern. First, the nulls between the side lobes translate directly to the fluctuations in signal strength described above. This can cause reflected signals from buildings or other objects in the vicinity, which are strong enough to cause an interference problem. Since the reflected signals are time delayed, there is the potential for a ghosting problem to result. The second problem is fluctuation of signal strength vs. frequency across the television channel bandwidth. This is referred to as "frequency response" or differential gain across the channel. Since the position of the side lobes in the antenna pattern tend to shift with frequency, the received signal levels can vary considerably at a given location in this region of the viewing area. This can result in degraded performance for the receivers in this area.

If a significant portion of the viewing audience is close to the transmit tower and affected by these phenomena, the station may have a marketing problem. The pattern shown in Figure 1 greatly reduces the potential for this type of problem by keeping the side lobe peak-to-null range to a minimal magnitude. However, for situations requiring the best possible consistency in near-in signal levels, an alternative is available in the smooth elevation pattern.

V. Smooth Elevation Patterns

Figure 1 shows another UHF 28-gain vertical plane radiation pattern. In this pattern, however, the side lobes have been nearly eliminated. This "smoothed" pattern exhibits a consistently decreasing field with increasing angle below the horizontal. There are virtually no peaks and nulls in the region near the tower discussed above. The nulls have been completely filled. Note also that the field level through this region is quite high, roughly the average of the peaks and nulls in the Standard pattern. Thus, signal level is not sacrificed to achieve the smooth pattern.

Figure 2 also shows the corresponding signal strength plot for the smooth pattern. A 1000 ft tower and the same ERP was assumed. It can be seen that the signal strength in this plot is quite consistent in the near in region (as well as everywhere else in the coverage area). Also note that the signal level in this region is still as high as the average level in standard pattern case. With the smooth pattern, a smooth signal strength curve can be achieved starting, essentially, right at the tower. For situations where the multipath and differential gain phenomena discussed above are a real concern, the smooth pattern, offered by ERI, is a solution.

References

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