ANOTHER LOOK AT SIDELOBE-FREE FM ANTENNAS

by Richard J. Fry, CPBE

Antennas with reduced sidelobes in their elevation patterns have been proposed as an advance in antenna designs for FM broadcasting. As stated in a previously published paper on this subject, [1] reducing or eliminating these sidelobes will:

[a] reduce blanketing interference
[b] better meet applicable ANSI/EPA/ FCC requirements regarding RF radiation hazards
[c] reduce or eliminate "source-induced multipath" from the sidelobes, which produce destructive interference in regions served by the major lobe of the antenna.

To evaluate the performance to be expected from sidelobe-free antennas, calculations were made by the author to show the radiated power density near the tower site for a six-bay, half-wave spaced array having all sidelobes suppressed more than 40dB. ERP was calculated at 0.1 degree intervals in the antenna elevation pattern, and that value was used with the appropriate formulas of FCC OET Bulletin 65 to calculate the power densities to be expected from the base of the tower out to a horizontal radius of about 2-1/2 miles.[2] The results are plotted in Figure 1, along with superimposed plots for a half-wave spaced array without sidelobe suppression, and a conventional full-wave spaced array. All antennas plotted have the same number of bays, the same maximum ERP, and the same height above level ground.

Blanketing Interference and RFR
Inspection of Figure 1 shows that, for these conditions, power densities from the sidelobe-free antenna starting somewhere around 1,000 feet from the tower[3] actually are higher than from standard antennas. In fact they are >20dB above the others at some portions of the range. The sidelobe-free antenna has generally less power density near the ground than the other two antennas only within ~950 feet of the tower base.

Figure 2 is a graphical representation of the portion of the nearby coverage area where power density from the sidelobe-free antenna exceeds standard antennas. This graphic is the output of a CAD program using equal and linear x and y axes, and shows the true relative areas.[4]

In this example, the standard antennas outperform a sidelobe-free antenna for control of blanketing and RFR over ~99% of the coverage area out to a radius of 2-1/4 miles. The reason for this is that for the same number of bays, the main lobe of a sidelobe-free antenna is significantly wider than a standard antenna, and at most close distances radiates higher ERP toward the ground. It also radiates higher ERP at many angles above the horizontal plane — which increases field strengths at airborne receivers. Both of these results are the reverse of popular expectations for the design.

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1 *Sidelobe-free Antenna Arrays*; Ali R. Mahnad, Ph.D., E.E. and Leroy C. Granlund.

2 For these conditions, radiated fields toward the horizon beyond 2-1/4 miles from the transmit site essentially are equal for all three antennas.

3 The actual range was determined from the calculation detail to be about 950 feet to 11,786 feet.

4 The x axis of Figure 1 is non-linear due to the fixed 0.1^{o} depression angle steps used in the power density calculations. This approach gives a better graphical display of the sidelobes.

Multipath Can reflections from terrain and objects illuminated by antenna sidelobes cause so-called "source-induced multipath" to areas served by the main lobe of the antenna? To produce serious multipath distortion at a receiver, a reflection must have an amplitude that is within about 10dB of the direct wave, and an RF phase that is destructive to that of the direct wave. The capture effect of the FM receiver largely ignores co-channel signals not meeting these criteria.

Consider that a reflection from terrain or objects located where sidelobes can illuminate them can be produced only very close to the transmitting site. It is unlikely that sidelobe energy arriving at those locations will have the grazing conditions necessary for highest level reflections toward the horizon, or that such a reflection will have the path geometry required for it to reach a distant point served by the main lobe of the antenna. Such sidelobe reflections likely would be blocked by terrain and/or man-made obstructions.

Another factor is the reality that a reflecting surface would have to be extremely close to an FM antenna (less than two feet, in general) in order to couple enough energy from the antenna to re-radiate it with only 10dB loss; besides which the sidelobes of a modern FM antenna also have considerably less power than the main lobe. Both of these factors, together with typical path losses mean that any energy received from a reflected sidelobe almost certainly will be more than 10dB reduced from that received from the main lobe, and so have little or no affect on a distant FM receiver.

Most multipath distortion is caused when the direct ray of the main lobe of the transmit antenna is obstructed at the receiving antenna, while reflected rays from one of more surfaces on a nearly identical azimuth and elevation angle toward the transmit antenna develop the net magnitude and phase delay required to interfere with it. Figure 3 illustrates this point.

This paper has examined and compared sidelobe-free antennas with standard antennas having sidelobes. The comparison used a specific set of conditions, but the conclusions will be applicable to most other conditions as well. The data shows the relative performance to be expected, and contains newly available information useful when evaluating and choosing an FM broadcast antenna.

Richard Fry is an FM Applications Engineer with over thirty years of experience with major broadcast equipment manufacturers. E-mail: rfry@adams.net

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Figure 1.

POWER DENSITIES FOR THREE SIX-BAY FM ANTENNAS
CALCULATED FOR 6' AGL USING FCC OET BULLETIN 65 METHOD
Radiation Centers = 500' Above Level Terrain, 50kW Maximum ERP Each
Element Function = Modified Cosine: 10% Relative Field at -90° Elevation

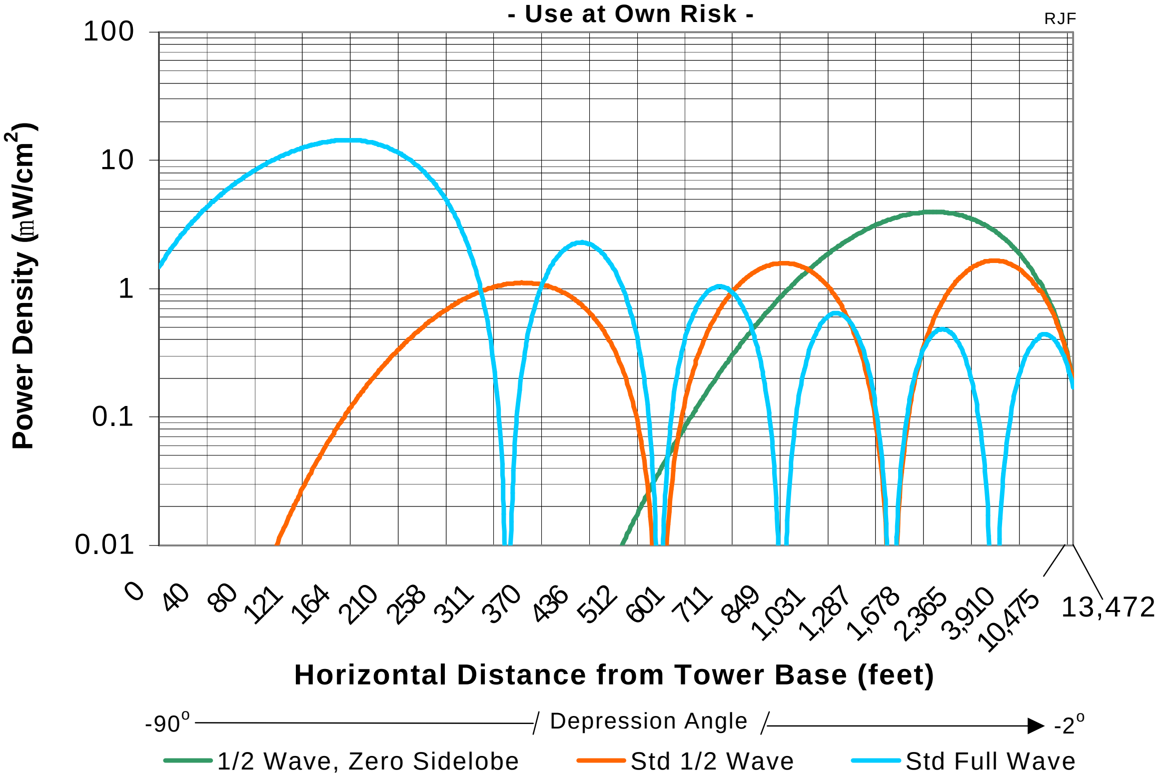


Figure 2: Area Comparison

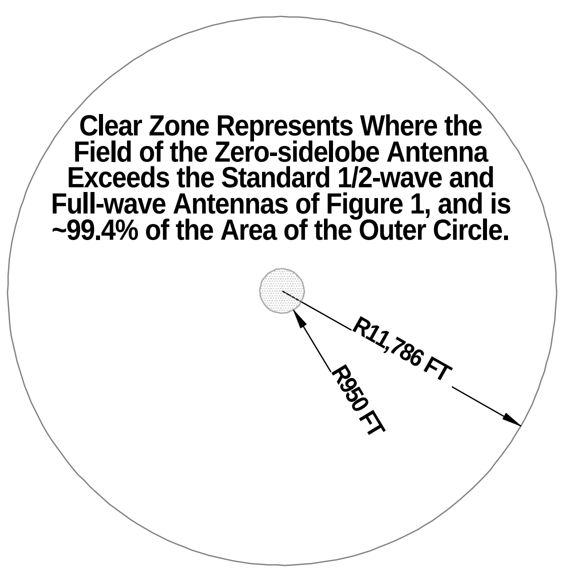
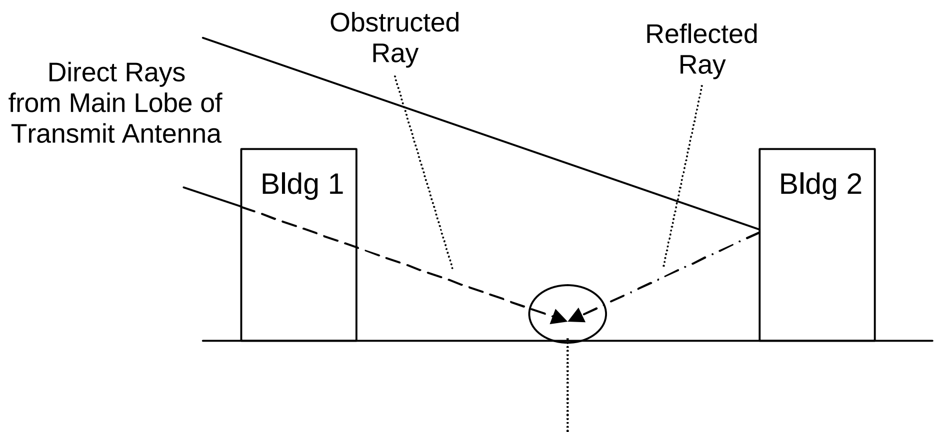


Figure 3. Typical Multipath Situation



Interference can occur when the net level of all reflected rays at the receiving antenna is within ~10dB of the direct ray, and has the required phase delay. For locations served by the main lobe of the transmitting antenna, these factors essentially are defined only by the physical environment "seen" by the receiving antenna.