FM ANTENNA Q & A

Richard J. Fry, CPBE

The following responses were prompted by questions posted on an Internet website.

Q. I'm having trouble serving some distant markets. Using my present transmit site, how can I improve my signal strength there? Should I use more height, more bays, less bays, or…?

A. This situation is likely to be more about the propagation path than the number of bays. Whether using 8 bays or 1 bay to produce a given nominal ERP, if antenna azimuth patterns are the same in/near the horizontal plane then the ERP toward distant markets near the radio horizon also will be the same, so field strengths there would not change.

Of course, raising the transmit antenna radiation center is always good, if that is an option. In the US, exceeding the maximum antenna height for the class of station means that the maximum ERP must be reduced, in order to maintain the same 60 dBuV/m contour as achieved at the maximum antenna height. But the higher antenna also means better path clearances for the direct ray and its Fresnel zones, which is the reason that distant field strength is maintained even with that lower ERP. This reality may improve distant field strength in some specific areas, depending on their path profiles.

But you might also consider this:

1. Commission a propagation study for your licensed ERP, site and antenna height, over the specific terrain to your problem area. From whatever field strength is predicted there for a 2m receive antenna height, subtract at least 10 dB to account for the losses caused by "urban clutter."

2. Measure the field strength at 2m receive antenna height for random locations in the problem area. Determine their average agreement to the end value from Step 1. If agreement is fairly close, probably your coverage there is all you can expect for that ERP, transmit antenna height and location. If not, go to Step 3.

3. Commission a pattern study from the antenna manufacturer using 2 bays (at least) of your antenna type mounted exactly as you have it on a model of your tower, including ladders, conduits etc. If the measured values of the h-pol and v-pol azimuth patterns are not at, or above the pattern RMS in the directions toward your problem zone, consider re-mounting the antenna at a different azimuth bearing on the tower, and/or add parasitics to smooth out the pattern so as to bring ERP up to nominal in that direction.

Every dB of ERP improvement produced by bringing up the pattern gain toward the problem zone will add another dB of field strength there.

Q. What affect do antenna beam tilt and/or null fill have on FM coverage?

A. Beam tilt is sometimes specified to direct the theoretical maximum antenna gain (ERP) directly at the radio horizon, rather than slightly above the horizon as it would be with no beam tilt.

This practice is most useful for high gain transmit antennas installed at very high elevations. Commercial TV broadcast transmit antennas often employ beam tilt, as the antenna gain and height details for TV applications make beam tilt more useful; particularly so for UHF.

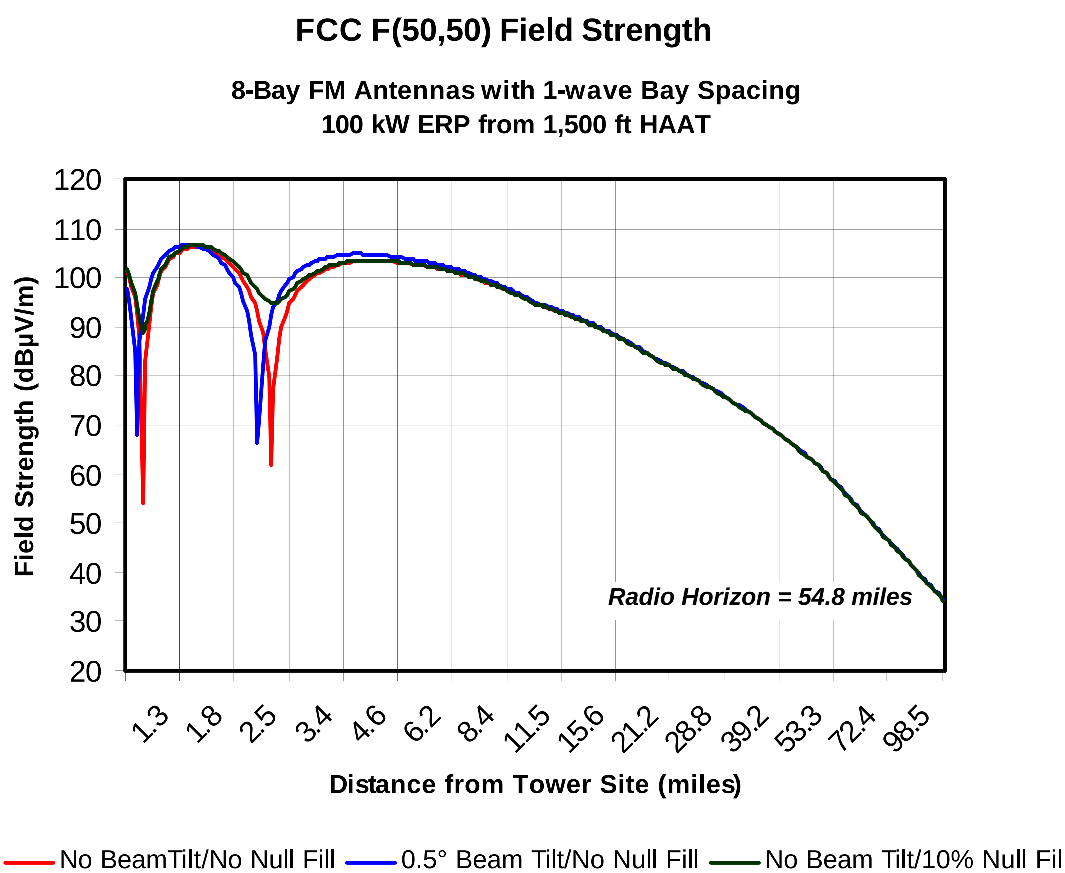
For the typical transmit antennas and antenna heights used in FM broadcast though, the practical effect of adding beam tilt is better understood as making slight changes in the aim of a floodlight, rather than a spotlight. Therefore the difference in distant field strength between an antenna with beam tilt and one with no beam tilt is virtually immeasurable for many installations.

This point is illustrated in Figure 1, which shows no practical difference in field strength at, or near the radio horizon for any of the three antennas plotted. Most of the field strength differences due to beam tilt shown in Figure 1 occur within about six miles of the antenna site — which is not the region of the coverage area where they usually are assumed to take place.

Null fill is useful when the natural nulls in the elevation pattern of an FM transmit antenna are directed at locations where a significant number of receivers are located. This situation can occur for certain combinations of transmit site location, antenna elevation pattern, and antenna installation height.

If unfilled, such nulls can cause zones of weaker-than-expected signal strength near the antenna, which may be prone to multipath distortion. Figure 1 shows the effect on nearby field strength when 10% first null fill is added to the 8-bay antenna of this example.

Figure 1



/RJF

Q. Does ½-wave vertical spacing of the transmit antenna bays provide improvement in distant coverage and/or building penetration there?

A. Distant coverage is provided by radiation toward and a few degrees below the horizontal plane. The main lobes of the elevation patterns of FM transmit antennas typically are within a dB or so of each other in this region, for bay counts up to at least 8, whether the antenna is full- or 1/2-wave spaced. So if the azimuth patterns and licensed ERP are the same, *any* antenna configuration would radiate very nearly the same ERP toward distant sites.

"Building penetration" is purely a function of the field strength outside the building. More field strength outside = more field strength inside.

The biggest contributors beside path loss to distant field strength are the h-pol and v-pol azimuth patterns of the transmit antenna. No matter how many bays, or what their spacing is, an FM transmit antenna might have a 10-15 dB null in its azimuth pattern when side mounted on a fairly large cross-section tower. Making sure that such a null isn't aimed at an important coverage sector is very important. That's the reason for the pattern study suggested earlier.

Q. Doesn't ½-wave vertical bay spacing greatly reduce the chance for blanket interference around the transmit site?

A. It can be useful, but probably the real-world blanket interference performance won't be as different as intuition might suppose.

Consider a 3-bay, 1-wave spaced antenna compared to an 8-bay, ½-wave spaced antenna. If both systems radiate 50 kW maximum ERP from a radiation center 180 feet above level terrain, and if the antenna patterns really are those assumed for them (a big 'IF'), then the fields from these two antennas will be identical beyond ~1/2 mile from the site.

In the "donut" between ~200 and ~2,500 feet from the tower, power density peaks for 2m above ground from the 8-bay, 1/2 wave antenna are ~7 $\mu W/cm^2$, and ~20 $\mu W/cm^2$ for the 3-bay, 1-wave antenna.

From zero to ~200 foot radius from the tower, the 8-bay antenna peaks at ~4.5 $\mu W/cm^2$, and the 3-bay at ~200 $\mu W/cm^2$. That's the large difference that intuition expects, but probably also it's a lot closer to the tower than expected. Chances are that not too many listeners are located there.

Figure 2 (p. 4) shows the two plots from which the above values were taken. Power densities were calculated for the OEM's published elevation patterns, and a perfectly omni azimuth pattern for a popular c-pol transmit antenna design.

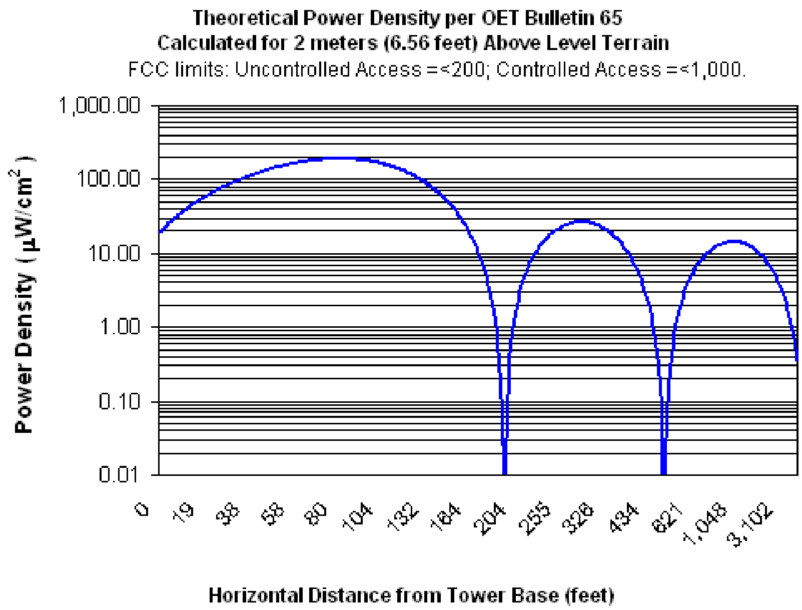
Sep 2004

Figure 2

COMPARISON OF POWER DENSITIES FOR TWO ANTENNA CONFIGURATIONS

Antenna: ERI SHP-3AE
Bay Spacing: 1 wavelength
Element Field @ -90: 12.6% (avg)
Far-field Pattern Assumed

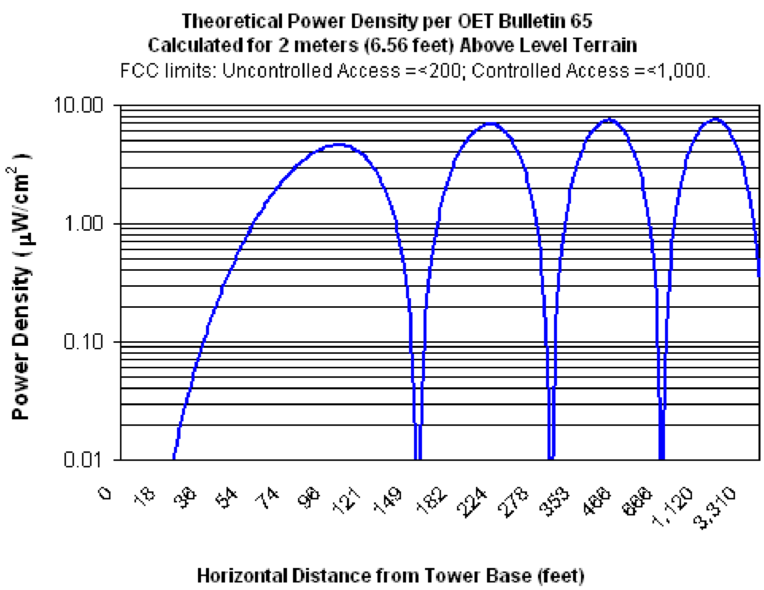
R/C Height AGL: 180 feet
Max. ERP per polarization 50.000 kW Analog
0.000 kW Digital (avg)
Date of Study: 28-Aug-04 / ID# 2



Calculation only for review and acceptance of station engineer or consultant.

Antenna: ERI SHP-8AE
Bay Spacing: 0.5 wavelength
Element Field @ -90: 12.6% (avg)
Far-field Pattern Assumed

R/C Height AGL: 180 feet
Max. ERP per polarization 50.000 kW Analog
0.000 kW Digital (avg)
Date of Study: 28-Aug-04 / ID# 1



Calculation only for review and acceptance of station engineer or consultant.

