

FIGURE 3 (Sheet 1 of 2)

General Design Formulae for Directional Antennae

A computer program utilizing the theoretical formulae modified in accordance with the Commission's Rules has been used to determine the final values of fields, RMS, RSS, etc.

The theoretical field is computed as follows:

$$E(\phi, \theta)_{th} = \left| k \sum_{i=1}^n F_i f_i(\phi) / \frac{S_i \cos \theta \cos(\phi_i - \phi) + \psi_i}{r} \right| \quad (\text{Eq. 1})$$

where:

- $E(\phi, \theta)_{th}$ Represents the theoretical inverse distance fields at one kilometer for the given azimuth and elevation.
- k Represents the multiplying constant which determines the basic pattern size. It shall be chosen so that the effective field (RMS) of the theoretical pattern in the horizontal plane shall be no greater than the value computed on the assumption that nominal station power (see § 73.14) is delivered to the directional array, and that a lumped loss resistance of one ohm exists at the current loop of each element of the array, or at the base of each element of electrical height lower than 0.25 wavelength, and no less than the value required by § 73.189(b)(2) of this part for a station of the class and nominal power for which the pattern is designed.
- n Represents the number of elements (towers) in the directional array.
- I Represents the i^{th} element in the array.
- F_i Represents the field ratio of the i^{th} element in the array.
- θ Represents the vertical elevation angle measured from the horizontal plane.
- $f_i(\theta)$ Represents the vertical plane radiation characteristic of the i^{th} antenna. This value depends on the tower height, as well as whether the tower is top-loaded or sectionalized. For a typical tower, which is not top-loaded or sectionalized, the following formula shall be used:

$$f(\theta) = \frac{\cos(G \sin \theta) - \cos(G)}{(1 - \cos G) \cos \theta}$$

where:

- G is the electrical height of the tower, not including the base insulator and pier. (In the case of a folded unipole tower, the entire radiating structure's electrical height is used.)

- S_i Represents the electrical spacing of the i^{th} tower from the reference point.
- ϕ_i Represents the orientation (with respect to true north) of the i^{th} tower.
- ϕ Represents the azimuth (with respect to true north).
- ψ_i Represents the electrical phase angle of the current in the i^{th} tower.

FIGURE 3 (Sheet 2 of 2)

General Design Formulae for Directional Antennae

The standard radiation pattern shall be constructed in accordance with the following mathematical expression:

$$E(\phi, \theta)_{std} = 105 \sqrt{[E(\phi, \theta)_{th}]^2 + Q^2} \quad (\text{Eq. 2})$$

where:

$E(\phi, \theta)_{std}$ Represents the inverse distance fields at one kilometer which are produced by the directional antenna in the horizontal and vertical planes.

$E(\phi, \theta)_{th}$ Represents the theoretical inverse distance fields at one kilometer as computed in accordance with Eq. 1, above.

Q is the greater of the following two quantities:

$$0.025 g(\theta) E_{rss} \quad \text{or} \quad 10.0 g(\theta) \sqrt{P_{kW}}$$

where:

$g(\theta)$ is the vertical plane distribution factor, $f(\theta)$, for the shortest element in the array (see Eq. 2, above; also see § 73.190, Figure 5). If the shortest element has an electrical height in excess of 0.5 wavelength, $g(\theta)$ shall be computed as follows:

$$g(\theta) = \frac{\sqrt{\{f(\theta)\}^2 + 0.0625}}{1030776}$$

E_{rss} is the root sum square of the amplitudes of the inverse fields of the elements of the array in the horizontal plane, as used in the expression for $E(\phi, \theta)_{th}$ (see Eq. 1, above), and is computed as follows:

$$E_{rss} = k \sqrt{\sum_{i=1}^n F_i^2}$$

P_{kW} is the nominal station power expressed in kilowatts, see § 73.14. If the nominal power is less than one kilowatt, $P_{kW}=1$.