A–8–3 OPTIMIZED LONG ROD REFLECTOR ANTENNAS

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Many practical reflector antennas are constructed with grids or rods as replacements for continuous sheet reflectors in order to reduce wind load and weight. The shape of such reflectors is commonly made the same as a portion of an infinite surface known to have particular or desirable properties. For example, corner reflector antennas using two grids at right angles are common, as are grid reflectors of parabolic shape.

In the transition from an infinite continuous sheet reflector to a finite grid reflector there are two implicit steps:

(i) reduction of infinite reflector size to finite

(ii) conversion from continuous sheet to grid.

There is no fundamental reason for expecting a reflector shape, so derived, to be optimum in any sense.

A grid or rod reflector antenna system can, in principle, be directly analysed, although in the general case the analysis is complicated. In order to obtain some insight into the problem, an analysis procedure has been developed for long rod reflector antennas for which the calculations can be reduced to a two-dimensional form. Examples of antennas in this category are large corner reflector and cylindrical parabolic antennas used for extended range VHF communications systems.

The configurations selected for the two-dimensional analysis are shown in Figures 1 and 2. The reflector shape in Figure 1 comprises a maximum of four linear segments, defined by the dimensionsA, B, C and D. The reflector shape in Figure 2 is parabolic and is defined by the half aperture A and focal length E. In each case the reflector is symmetric about the central axis on which is located the line source feed at dimension F. The reflector rods are equally spaced on the reflector surface and are parallel to the line source.

The reflector rod diameter is assumed to be small enough that there is no circumferential variation of current. The rod diameter is, however, an important parameter as it determines the self impedance of each rod. The reflector rods are assumed perfectly conducting.

A set of simultaneous equations with Hankel function coefficients is set up using the boundary condition of zero tangential E on the surfaces of the rods. Because of the symmetry of the structure, the number of equations is equal to one half the number of reflector rods. After the rod currents have been determined by the Gauss-Seidel procedure, the gain (two-dimensional) is calculated from the forward field and the real part of the input impedance of the line source. The radiation pattern is then calculated, and integrated to confirm the gain calculation. A routine is available whereby the gain can be maximised with respect to any or all of the dimensional parameters in either reflector configuration.

The example to follow is for 20 reflector rods (10 on each side of the axis) of radius 0.005 wavelengths. The initial case is for a linear reflector with A=B=0.5λ, C=D=0, F=0.35λ, a common 90° corner reflector configuration. The radiation pattern is shown in Figure 3, and the two-dimensional gain relative to a line source is 5.14. After the parameters A, B and F have been adjusted for maximum gain (i.e. the structure is a corner reflector of arbitrary side length, angle and feed distance) the pattern is as shown in Figure 4. For this case A=1.17λ, B=1.08λ, F=0.62λ, gain=8.83. If instead all the parameters A, B, C, D and F are optimized the resultant pattern is shown in Figure 5, with corresponding values A=1.35λ, B=1.56λ, C=0.60λ, D=0.14λ, F=0.29λ, gain=11.31.

If the 20 rods of the above example are located on a parabolic shape of the same aperture and depth as for the linear reflector case of Figure 5, and the three parameters A, E and F are then optimized, the resultant pattern is shown in Figure 6. The values for this configuration are A=1.31λ, E=0.30λ, F=0.37λ, gain=10.78.

It is of interest that the gain for the parabolic shape is slightly less than that for the four segment linear shape. A similar result has been obtained for different numbers and radii of the reflector rods. A possible explanation for this result is as follows. The gain is a very complicated function of the locations of all reflector rods, and maximum gain would be obtained if the rod positions were individually adjustable. In the analysis, there are the constraints of equal spacing along the reflector surface, and the need to conform to the reflector shape specified. The linear reflector case has more degrees of freedom to be optimized, and it may reach a higher gain than a case with fewer degrees of freedom.

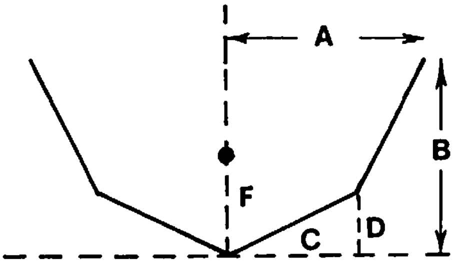

FIG. 1. LINEAR SHAPE

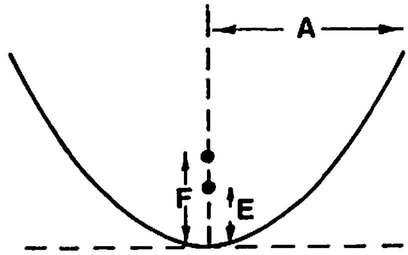

FIG. 2. PARABOLIC SHAPE

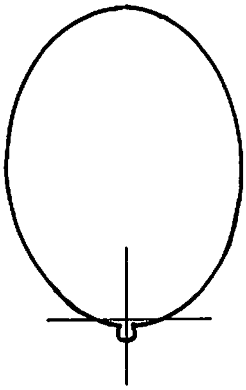

FIG. 3. INITIAL PATTERN

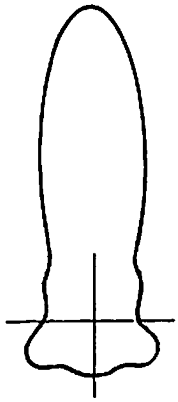

FIG. 4. A, B, F OPTIMIZED

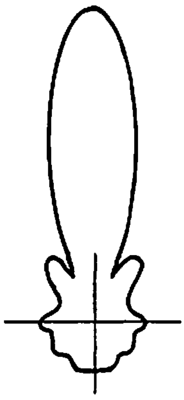

FIG. 5 A,B,C,D,F OPTIMIZED

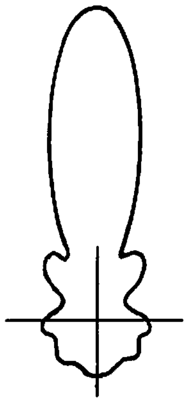

FIG. 6. A, E, F OPTIMIZED