A NEW TORUS ANTENNA WITH MODIFIED GENERATRIX REVOLVING ABOUT BIAS AXIS

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The parabolic torus can be used to scan or make mutlibeams on the plane or cone. But the aberrations on the aperture along the intermediate plane between the neutral plane and the perpendicular plane are so large that the performance of the antenna may be lower.

In this paper, using a new modified generatrix in stead of parabola revolving about bias axis, a new type torus with better performance has been made.

Fig.1 shows the graph of torus with inclination angle α between the axis of generatrix and the revolving axis, where X-Z plane is neutral plane. Because of the symmetry about X axis, the performance of other son-beams can be obtained by studying the performance of son-beams on the X-Z plane.

In order to simply the calculation and to explore the new modified generatrix conveniently, let α=90 and the formula of modified generatrix on the neutral plane is given:

$$R-z=\frac{x^2}{4f}+A+Bx+Cx^2+Dx^3 \qquad (1)$$

When A, B, C, D=0, the generatrix is degenerated into a parabola.
where F=the focus of the parabola, also the phase center of the prime feed.
T(0, 0, R)=the Vertex of the parabola.
$\bar{L}$=the axis of the parabola.
$\bar{x}$ =the revolving axis
α=the angle between the axis of parabola and the revolving axis
f=focal length of the parabola
When A, B, C, D are not zero, the new modified generatrix is obtained.

The formula of the new torus by revolving the new modified generatrix about the axis X is given as follow:

$$z=\sqrt{(R-\frac{x^2}{4f}-A-Bx-Cx^2-Dx^3)^2-y^2} \qquad (2)$$

When A, B, C, D=0, the formula(2) is degenerated into the formula of the parabolic torus.

It is difficult to calculate the aberration directly, so a clever processing is made as follow: An offset parabolic antenna is made as contrast object, in which the generatrix is the same as the parabolic torus with the revolving axis is $\hat{z}$, other than $\hat{x}$. The formula of this contrast object is given as follow:

$$x^2 + y^2 = 4f(R - z_1) \qquad (3)$$

Where co-ordinate variable z has a subscription "1" which is different from the co-ordinate variable z on the son-reflector . The aperture of the contrast object S_A which is perpendicular to the axis $\hat{z}$, has the circle center $(X_0, 0)$ with radius a. The optical range of all rays on the aperture are equal, when placing the phase center of prime feed on the focus F of the parabola. The half aberration δ of son-beams can be obtained by calculating the contour error ΔZ form the son-reflector of modified torus to the contrast object reflector as follow:

$$\delta = \Delta z(\cos\frac{\varphi}{2})^2 \qquad (4)$$

Where:

$$\varphi = \cos^{-1}\frac{f-(R-z_1)}{[(f-R+z_1)^2+x^2+y^2]^{1/2}} \qquad (5)$$

$$\Delta z = z - z_1 \qquad (6)$$

Substituting equations (2) and (3) into equation(6), we obtain:

$$\Delta z = [(R - \frac{x^2}{4f} - A - Bx - Cx^2 - Dx^3)^2 - y^2]^{1/2} - R + \frac{x^2+y^2}{4f} \qquad (7)$$

mean-square error of the half aberration weighted by the strength of rays is given as follow:

$$\sigma = [\frac{W}{G} - (\frac{H}{G})^2]^{1/2} \qquad (8)$$

Where:

$$W = \iint_{S_A} (\cos\theta)^n (\cos\frac{\varphi}{2})^2 [\Delta Z(\cos\frac{\varphi}{2})^2]^2 ds \qquad (9)$$

$$H = \iint_{S_A} (\cos\theta)^n (\cos\frac{\varphi}{2})^2 [\Delta Z(\cos\frac{\varphi}{2})^2] ds \qquad (10)$$