RADIATION PATTERN COMPUTATION OF A CHOKE-LOADED CYLINDRICAL REFLECTOR ANTENNA

Katsumasa Miyata

Electrical Engineering Department
Akita National College of Technology

and

Ichiro Fukai
Faculty of Engineering
Hokkaido University

1. Introduction

Radiation patterns of a cylindrical parabolic reflector antenna with chokes at the reflector edge are computed by using a boundary-element method(BEM) which in recent years is being recognized as a powerful tool for electromagnetic field problems[1]-[5]. One of the attractive features of BEM in the analysis of radiation pattern copmputation of a reflector antenna is that we are not required to pay any particular attention to a so-called shadow boundaries of the considering antenna. Simultaneously , we need not be anxious about troublesome PO(Physical Optics)/GTD(Geometrical Theory of Diffraction) combination when computing the reflector overall radiation patterns. Numerical computation was conducted by using a super-computer at Tohoku University.

2. Reflector geometry and numerical examples

The cylindrical reflector antenna to be considered here is illustrated in Fig.1. In the BEM analysis, one of the first steps to be taken is to specify nodal points on the reflector system, and this is shown in the figure. The first node is given to the back end of the parallel-plate feed antenna whose aperture is fixed at the reflector focus. The length between the nodes is chosen less than $\lambda/10$(λ : wavelength) here, and the node(no. 120) which lies at the bottom of the feed is chosen as the last node for the primary feed. The node 121 is given to the apex of the cylindrical reflector and the last node for the whole antenna system is N; N depends on the number and on the dimension of the chokes to be loaded at the reflector edge. Since the model is of axial symmetry with the Y axis, the nodes are given on the lower half of the antenna. In this numerical example, the depth , wall thickness, and width of the feed are chosen as 10.0 cm, 0.2 cm, and 2.29 cm, respectively. As for the main reflector, the aperture width(D) and F/D ratio(F; focal length) are chosen 80.0cm and 0.25, respectively.

Fig. 2 illustrates the whole-angle radiation patterns of a non-choked antenna for three frequencies; f=8, 10, and 12 GHz, where the vertical and the horizontal axes represent the relative power levels in dB normalized by each mainlobe peak value and azimuthal angles, respectively. The distance R between the refrector focus and the observation point P is 30 m. It is shown that there is no infinity at the reflector shadow boundary; the levels at this angle are found to be continuous. As stated in the introduction, no particular procedure for obtaining the fields at this angle is taken. Fields at any observation points in space are computed by simply specifying the observation points and by using the evaluated results of the linear equation formed for the whole radiating system. In other words, there is no computational difference between the so-called near-fields and far-fields, or between the near-axis and wide-angle patterns. The interference patterns for the reflector backward direction due to the diffraction from the reflector edges are computed likewise. In order to compare the efects of choke loading for wide-angle sidelobe suppression, the F/B ratios(envelope) of a non-choked antenna versus frequency are first considered. The values for f=8, 10, and 12 GHz are -63.2, -64.5, and -74.8, respectively.

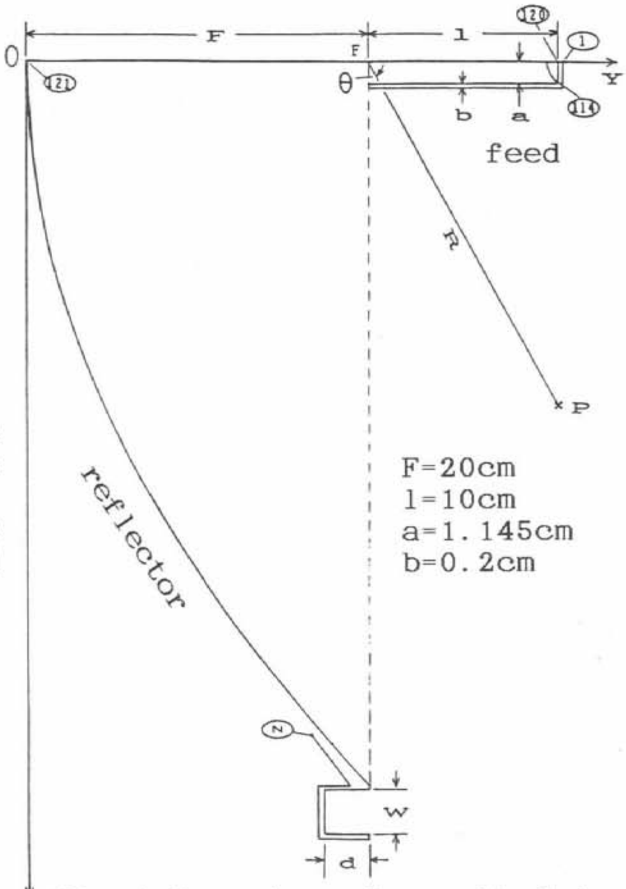

Fig. 1 Geometry of a cylindrical reflector

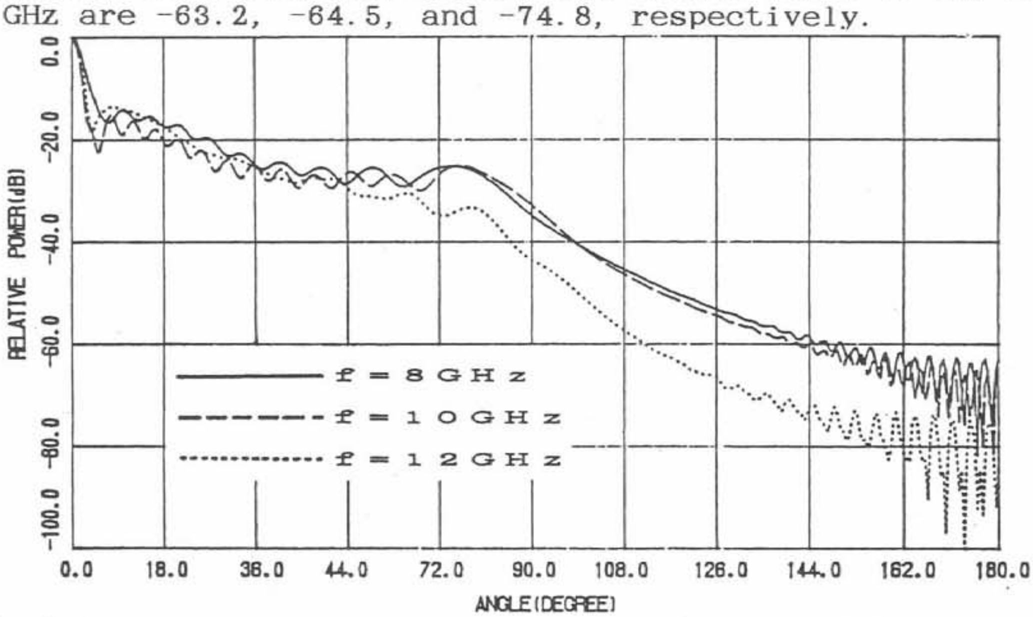

Fig. 2 An overall radiation patterns of a non-choked antenna

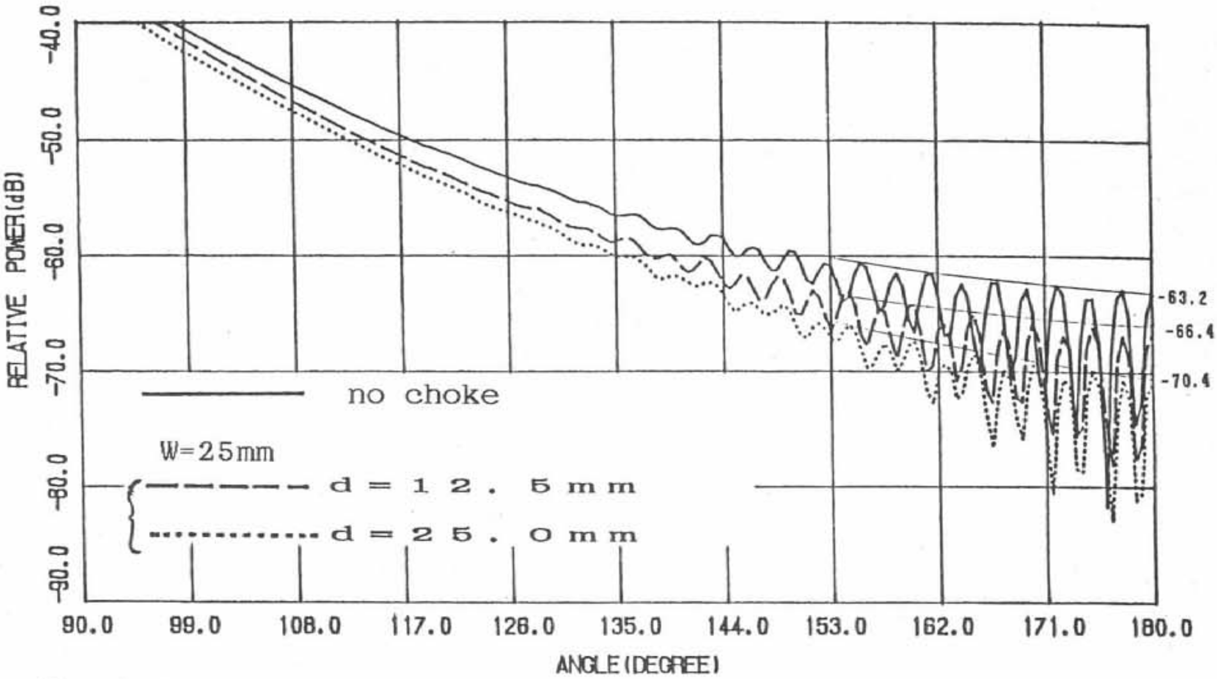

Fig. 3 Wide-angle radiation patterns of a choked reflector antenna(f=8 GHz, W=25mm).

Next in Fig. 3 are shown wide-angle patterns of a reflector for two types of chokes at f=8 GHz, where choke width(W) is fixed 25 mm, and its depth(d) is changed (d=12.5mm and 25.0mm). As only the wide-angle sidelobe levels are considered, the patterns for the reflector forward region including the mainlobes are not shown in the figure. The backlobe levels(envelope approximation) for non-choked antenna(solid line), choked antenna(W=25mm, d=12.5mm), and that for (W=25mm, d=25mm) are observed to be -63.2 dB, -66.4 dB, and -70.4 dB, respectively. This shows that wide-angle sidelobes may be suppressed by loading chokes at the reflector edge.

F/B ratios versus choke depth(d) of the same reflector antenna with frequency as parameters are illustrated in Fig. 4. The F/B ratios are observed to improve as d increases, though not necessarily proportional to the choke depth. The amount of the improvement of the case (d=27.5mm) for the choke-free case at f=8 GHz, for example, is about 8 dB.

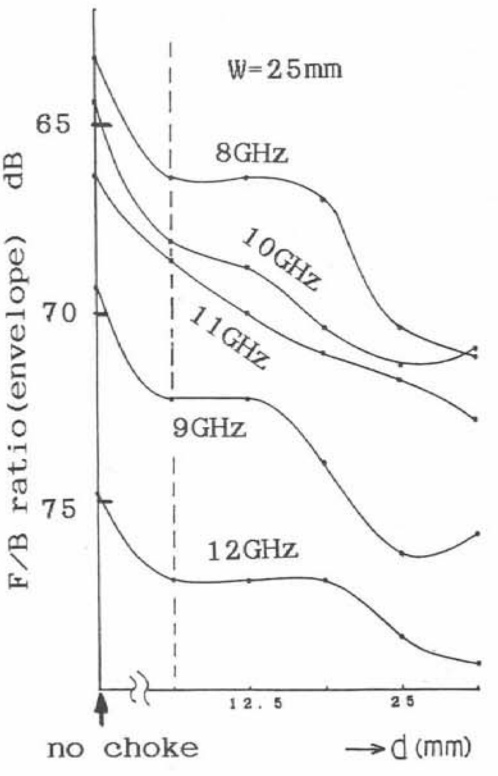

Fig. 4 F/B ratio versus choke depth

3. Conclusion

Radiation patterns of a choke-loaded cylindrical reflector antenna were computed by BEM. In the actual computation, a supercomputer(SX-1) installed at Tohoku University was used. Hankel function of the second kind and order 0 was used as the Green's function in the formulation of the Helmholtz equation. In this paper, the Hankel function was approximated by polynomials so that so-called the "vectorization ratio" is increased and high speed computation taking advantage of the array processor is realized.

REFERENCES

[1] C. A. Brebbia:"The boundary element method for engineering", Pentech Press(1978).

[2] K. Miyata and I. Fukai:"A cylindrical reflector antenna pattern computation by boundary element method", IEEE/AP-S Int. Symp. Digest. vol. 1, pp. 518-521, (Virginia USA), 1987.

[3] S. Washisu and I. Fukai:"An analysis of electromagnetic unbounded field problems by boundary element method", Trans. IECE Japan, J64-B, pp. 1359-1365(Dec. 1981).

[4] S. Kagami and I. Fukai:"Application of boundary element method to electromagnetic field problems", IEEE Trans. Microwave Theory Tech., vol. MTT-32, pp. 455-461, April 1984.

[5] H. A. El-Mikati and J. B. Davis:"Improved boundary element techniques for two-dimensional scattering problems with circular boundaries", IEEE Trans. Antennas Propagat., vol. AP-35, pp. 539-544, May 1987.