2-III C4 SOME PROPERTIES OF APERTURE ANTENNAS WITH A CIRCULAR IRIS IN THE FRESNEL REGION

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Introduction

A theoretical study of an antenna used with a plane reflector was presented by Jakes who assumed the incoming field to be a uniform plane wave.[1] However, the theoretical analysis of the antenna-reflector problem is difficult when both the transmitting and the receiving antenna lie in the Fresnel region of the reflector. Another approach to solve this problem is to consider an antenna system used with an iris. This paper gives theoretical and experimental studies on the behaviour of K-band wave, radiated from a circular aperture and diffracted by a circular iris in the Fresnel region, and some properties of an antenna system using two paraboloidal antennas coupled by a circular iris in the Fresnel region.

The numerical analysis of these problems is based on the Kirchhoff's integral, assuming the field over the antenna aperture to be circularly symmetric and have the Gaussian amplitude illumination.

In the experiment, a 50-cm diameter paraboloid reflector with a focal length of 25-cm is used at 24-GHz as the aperture antenna. The circular iris is made of metal plate, both sides of which are covered with absorber.

Radiation properties of the primery feed horn

The antenna used in the experiment is illuminated by means of a small pyramidal horn. In order to investigate the radiation properties and determine the phase center of this horn, the precision measuring equipment is used. Fig.1 shows measured radiation patterns both in amplitude and in phase.

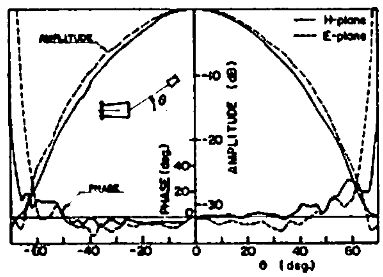

Fig. 1. Radiation patterns of the small pyramidal horn

Small undulations are observed, and the wave front can be regarded as a sphere within the region of the angles of ±50° around the horn axis. The center of the spherical wave front is located very near to the center of the aperture of the horn.

Diffraction phenomena

The iris of a diameter 2b is perpendicular located on the axis of the transmitting antenna of a diameter 2a at a distance S_1 apart. In Fig.2, the power density P_z of the diffracted wave by the iris along its axis, in case of a=25cm, b=20cm, and S_1=3m, is shown. The density is normalized to that of the same point when the iris is not used. Fig.3 shows diffraction patterns for two values of S_2 in the same case as described above.

Power concentrations of the diffracted wave around the antenna axis are observed. These phenomena are not strongly depend upon the values of a and S_1, but upon the value of b. The diffracted wave front near around the antenna axis is similar to the incident wave front and can be regarded as a plane.

In the experimental investigations on these phenomena, the stabilized

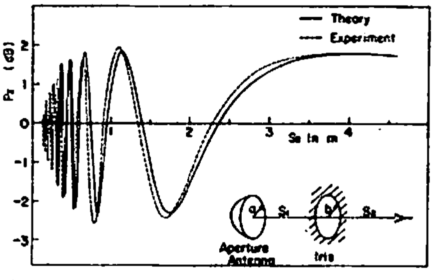

Fig 2 Power density along the antenna axis

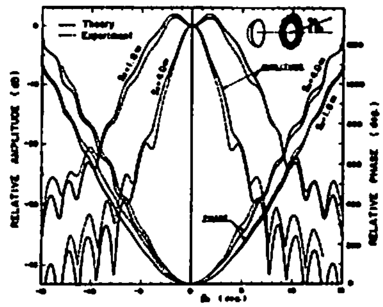

Fig. 3. Diffraction patterns for S = 1.8m and 4.0m

klystron oscillator and the measuring equipment of high accuracy in moving the receiving horn antenna, are used. The experimental results are shown in Fig.2 and Fig.3 as broken lines. They are in good agreement with the computed values. The influence of the conductivity of the edge of the iris on the diffracted field is negligible except the slight increase of the sidelobes.

Antenna system using an iris

Consider the coupled system of two paraboloidal antennas and an iris as shown in Fig.4. The transmitting and the receiving antennas are of the same shape and have the same illumination over the aperture. The ratio of the received power Pr of this system to the received power Pr^{0} when the iris is not used, is reffered to η ($=Pr/Pr^{0}$) as Iris-Efficiency. Fig.4 shows computed Iris-Efficiency for $r=S_1/(S_1+S_2)=0.5$ and various values of $h=a/b$, as a function of $Y=S/ka^2$, where $k=2\pi/\lambda$. Fig.5 shows also η for h=0.5 and various values of Y, as a function of r.

The system using an iris is effective even when the distance S is

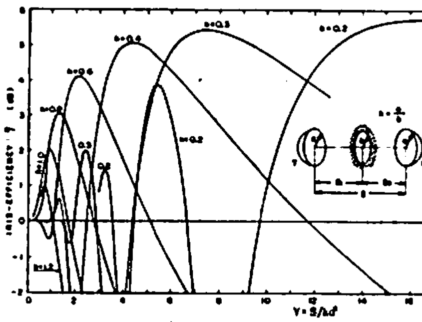

Fig. 4 Computed Iris-Efficiency for r=0.5, as a function of Y=S/ka²

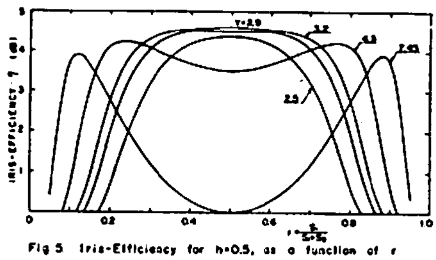

Fig 5 Iris-Efficiency for h=0.5, as a function of r

considerably large, and the value of η is not depend upon the position of the iris if suitable values of Y and h are chosen.

Displacing the primery feed horn of a paraboloid reflector from its focus along the axis is called "focusing". Numerical computation shows that the effect of the focusing on the antenna system as described above is exaggerated at a short distance. Fig.6 shows η for three values of the iris diameter (2b=34,40,50cm), as a function of the value of focusing ϵ (in case of $S_1=S_2=15$m). Experimental results are in good agreement with the computed values.

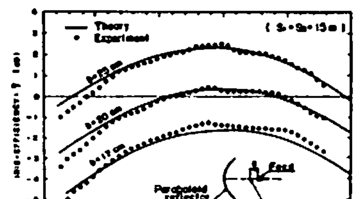

Fig. 6 Iris-Efficiency as a function of ϵ

Reference

1) W.C.Jakes, "A Theoretical Study of an Antenna-Reflector Problem," Proc. IRE, vol.41, pp.272-274, February 1953.