ANALYSIS OF CIRCULAR REFLECTORS BY COMPLEX SOURCE-DUAL SERIES APPROACH

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I. INTRODUCTION : Complex source(CS) approach is a very efficient way of taking account of source directivity in the reflector antenna simulations[1], since, the simple replacement of the real source position with the complex one creates a beam field. In [2], Jull and Suedan used the CS method in combination with aperture integration(AI) and geometrical theory of diffraction(GTD). However, it is well known that GTD fails at the main beam region and AI at sidelobes. The acceptable accuracy is also unpredictable in both methods. On the other hand, numerical techniques like Method of Moments may be inefficient or inaccurate for electrically large reflectors. Therefore, an accurate technique to create reliable reference data for reflectors with directive sources is still needed.

In the present paper, two dimensional circular reflector antennas are analyzed by a rigorous analytical-numerical technique for both E and H polarization cases. The method is used in combination with the complex source approach. The convergence of the solution is guarenteed and any desired accuracy can be obtained. Some principal results of reflector antennas are examined by the exact circular reflector solution.

II. ANALYSIS : A perfectly conducting and infinitely thin circular reflector in two dimensions is excited by a directive feed pattern. The geometry of problem is shown in Figure 1(a). The aim is to obtain the far-zone radiation pattern of the reflector antenna system. The pattern of the feed is simulated by complex source approach. This is performed by replacing the real source position vector $\vec{r_o}$ with the complex position vector $\vec{r_s}$ defined as $\vec{r_s} = \vec{r_o} + i\vec{b}$ where $i\vec{b}$ represents the beam directivity and position.

The problem is first formulated by dual series equations. Then, it is converted into a certain canonical form and solved by using Riemann-Hilbert Technique. The method is based on the partial inversion of scattering operator. Resulting matrix equations enable one to conclude about two facts of primary importance. First, the exact so-

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lution really exists, and second, it can be approximated by solving truncated equations of large enough order. The details of the method is explained in [3]. Further, it is known that a parabola can be approximated by a part of a circle with a great accuracy[4]. The circle has a radius that is twice of the focal length of parabola. The maximum electrical length which the parabola deviates from circle is defined as electrical length of error(i.e. Δ). Following [4], one can assume that acceptable electrical error is $\lambda/16$ and Figure 1(b) gives the domain of reasonable validity of the approximation in terms of δ and ka.

III. NUMERICAL RESULTS : The radiation patterns of the circular reflector are obtained for various cases using the dual series based Riemann-Hilbert Technique. Figure 2(a) shows the comparison of E and H polarization cases. Since the edge effects are stronger for H-polarization, the side lobe levels are also higher. The circular reflector result is used to approximate the radiation pattern of a parabolic reflector. Figure 2(b) represents the comparision of the circular reflector solution with the parabolic reflector result of Jull and Suedan[2]. In addition, the effect of increasing source directivity for both polarizations is examined in Figure 3. Source directivity is increased with increasing kb and the results show that the side lobe levels are decreased and the main beamwidth is increased. Figure 4 shows the radiation patterns of E and H polarization cases for different aperture dimensions. The edge illumination is -13.5dB below the aperture center for a reflector with f/D=0.5 and the aperture dimensions are taken as 10λ,20λ and 30λ. It is seen the beamwidth is narrower for a large aperture and sidelobe levels are more depressed.

IV. CONCLUSIONS : The CS approach is used with Dual-Series formulation for reflector antennas in two dimensions. By the present numerically exact solution, some principal results of reflector antennas are checked for a circular reflector. The results are compared with the results in [2] for a parabolic reflector. Some other parameters of reflector antennas like gain and radiation resistance can also be obtained by the method. Further, the method provides an opportunity to analyze the performance of reflector antennas over a ground plane or inside a radome.

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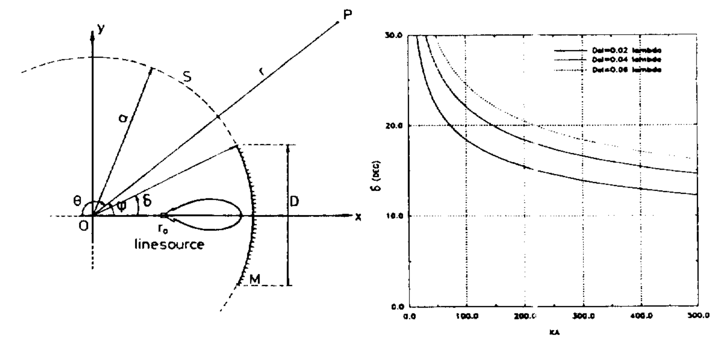
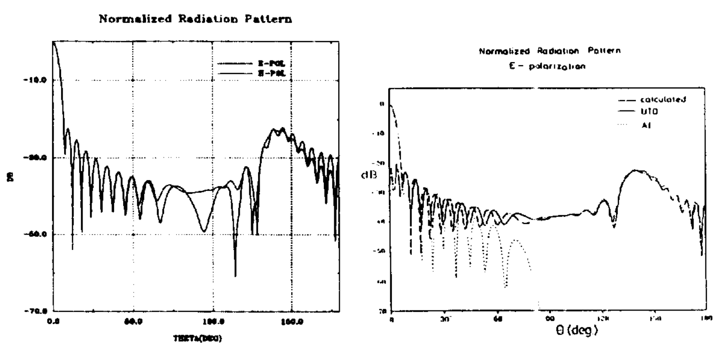


a) b)

Figure 1: **a) Circular reflector antenna system b) Electrical length of error (i.e.Δ(Del))**



a) b)

Figure 2: **a) Comparision of E and H polarizations for circular reflector ka=120.57, kro=60.28, kb=9.06 and δ=15 deg(D=10λ). b) Prediction of the radiation pattern of parabolic reflector. (f/D=0.96 and D=10λ)**

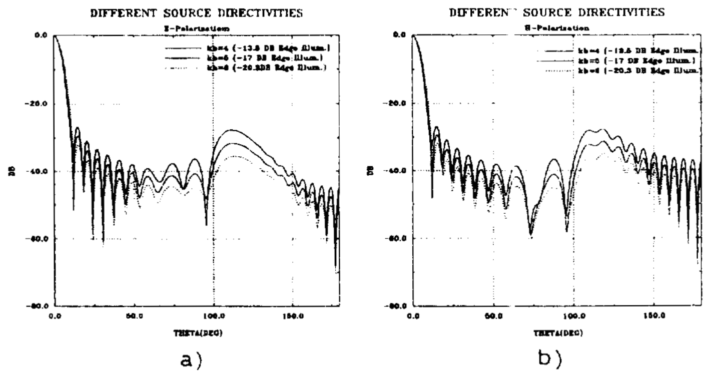


Figure 3: **Different source directivities ka=62.8, kro=31.4 and δ=30 deg(D=10λ). a) E-polarization case b) H-polarization case**

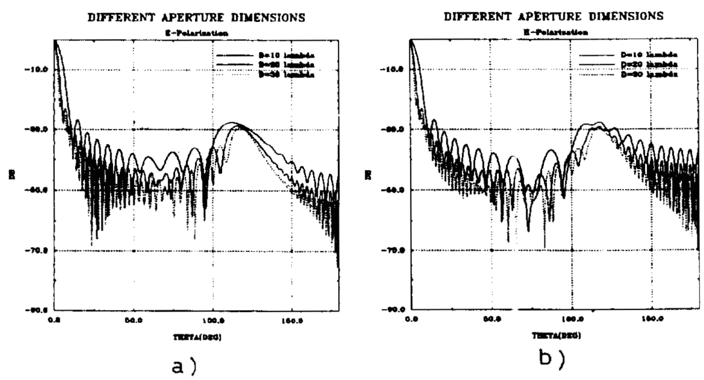


Figure 4: **Different aperture dimensions. δ=30 deg, kb=4(-13.5 DB edge illumination). a) E-polarization case b) H-polarization case**