

**MODELLING A RESISTIVE-REFLECTOR ANTENNA
BY THE COMPLEX SOURCE - DUAL SERIES APPROACH:
THE 2-D CASE OF H-POLARIZATION**

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INTRODUCTION

Reflector antenna simulation is normally performed under an assumption of the perfect conductivity of reflector. Such antennas have been studied by using high-frequency asymptotic approaches like Physical Optics (in particular, Aperture Integration) [1], Geometrical Theory of Diffraction [2], ray tracing, etc., and numerical ones as Method of Moments (MoM) [3]. We have failed to find any published paper dealing with a resistive or impedance-surface reflector, and so we suppose that our analysis of resistive reflector beamforming can be of potential interest. Meanwhile, even for a perfectly conducting geometry, MoM results in prohibitively large CPU time, if a reflector is larger than 20λ . What is even more disappointing, MoM is known to be heavily inaccurate if a kind of resonance takes place [4]. Therefore, in our analysis we use the Method of Regularization (MoR) modified by us for solving the scattering from a curved resistive strip [5]. Besides, to simulate a directive feed in equally accurate manner, we use the Complex Source Method (CSM) [6]. The latter is known as a very efficient way to account for the feed directivity without losing a mathematical correctness. Worth noting also is the fact that here no problems occurring in ray-tracing analyses appear, for blending the real-space edge diffraction points with complex-space reflection points. Thus, the presented here analysis is a recent development of our previous works [7-9].

ABOUT THE ANALYSIS METHOD

In the H-polarization case, the integral equation for the electric current $J(r)$ induced on the surface of a zero-thickness resistive reflector with the resistivity R can be written as in [10], p. 205:

$$(1/2)ikR + \frac{\partial}{\partial n} \int_M J(r') \frac{\partial}{\partial n'} G(r-r') dr' = -E^{in}(r), \quad r \in M \quad (1)$$

Here, we take the right-hand-part as the field of a complex point source, of the directivity factor kb , placed at the point r_0 . That is,

$$E^{in}(r) = CH_0^{(1)}(k|r-r_0-ib|) \quad (2)$$

Further, instead of solving (1) by MoM directly, we convert it to the dual series equations [5,7-9], in terms of surface current angular coefficients. Then, we extract the *static* part of the kernel, and also, the part corresponding to the *circular* shape of the reflector. By using the set of eigenfunctions of this partial operator as expansion functions, we obtain finally a *regularized* matrix equation, i.e., that of the Fredholm 2-nd kind:

$$X = [A^{(o)} + A^{(imp)} + A^{(sh)}]X + B, \quad (3)$$

where $X = \{x_n\}_{n=-\infty}^{\infty}$, $A^{(o,imp,sh)} = \{A_{mn}\}_{n,m=-\infty}^{\infty}$, $B = \{B_n\}_{n=-\infty}^{\infty}$.

Here, the operator $A^{(sh)}$ vanishes if the true shape of reflector is the circular one, $A^{(imp)}$ vanishes for the perfectly conducting geometry, and all the elements of $A^{(o)}$ and $A^{(imp)}$ are obtained analytically, i.e., no numerical integrations are needed. In the practical computations, it has been verified that the p -digit

accuracy is achieved by taking the matrix truncation number as $N=(1+|R|)ka+(p-1)^2$, independently of the reflector's angular width, where a is the curvature radius at reflector's edge.

SAMPLE NUMERICAL RESULTS

Below, we demonstrate the effect of a thin lossy resistive reflector on the far-field radiation pattern, the total radiation power, and the directivity. We emphasize that these basic effects are obtained here with a uniformly guaranteed accuracy of 0.1%, for the adopted mathematical model. All the mechanisms such as reflector's surface curvature effect, power loss and resonance phenomena, guided and leaky waves contributions, etc., are inherently and exactly contained in our solution.

To simplify the computations, we took a circular reflector of the size $D=10\lambda$ and focal distance $F=0.5D$ - see Figure 1. Further, in order to simulate the frequency dependent character of resistivity, we postulated that

$$R=i(\epsilon)^{-1/2}\tan [k(\epsilon)^{1/2}d] \quad (4)$$

Computed and compared in Figure 2 are the radiation patterns for the perfectly conducting reflector (zero resistivity), and for two values of the constant ϵ of the $d=0.01a$ thickness reflector (matched and unmatched reflector). The reflector edge illumination is -10 dB. One may see clearly that due to the resistivity, the reflector becomes partially transparent, and rear-zone sidelobes get higher, disturbing the radiation pattern significantly. If the reflector thickness is not matched, the drop in the directivity value can reach 100%, and the part of the source power is now lost for absorption - see Figures 3 to 5. The way to match the reflector is to take its thickness approximately equal to an integer number of the half-wavelengths in reflector material. This value is the total reflection value for a plane wave incident normally to a flat-slab lossless resistive layer. The optimum thickness needed to maximize the coated antenna directivity is shifted from this value: the smaller the reflector radius, the greater the shift.

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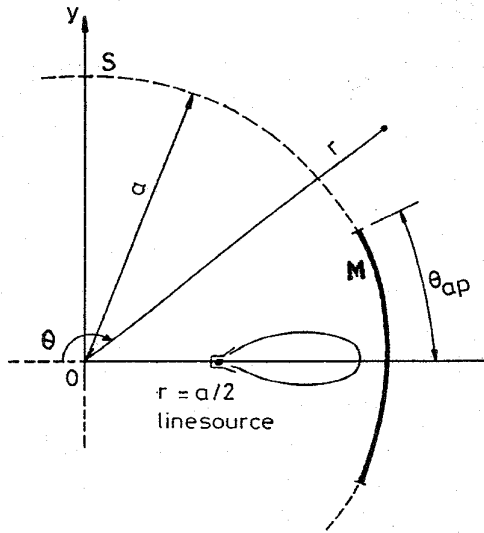


Fig. 1 Geometry of a 2-D circular-reflector antenna normally fed by an in-focus source.

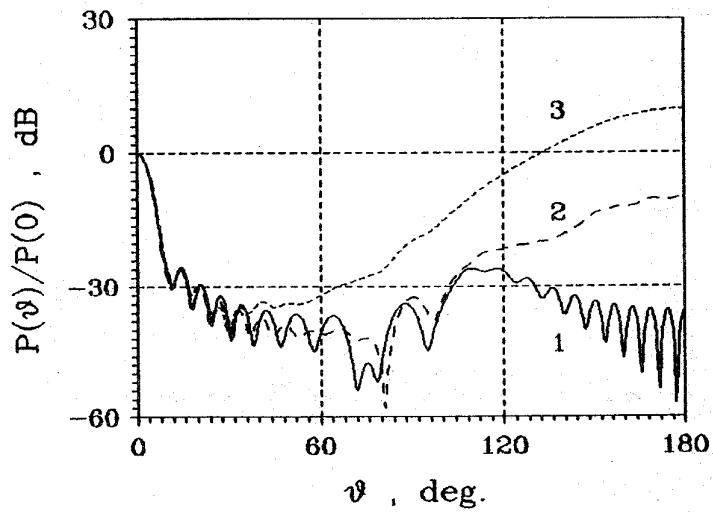


Fig. 2 Normalized radiation patterns of perfectly conducting and resistive $10\text{-}\lambda$ reflectors. $ka = 62.8$, $\Theta_{ap} = 30^\circ$, $kb = 3.5$, (1) $R = 0$, (2) $R = 0.02 - i2$, (3) $R = 10 - i7$.

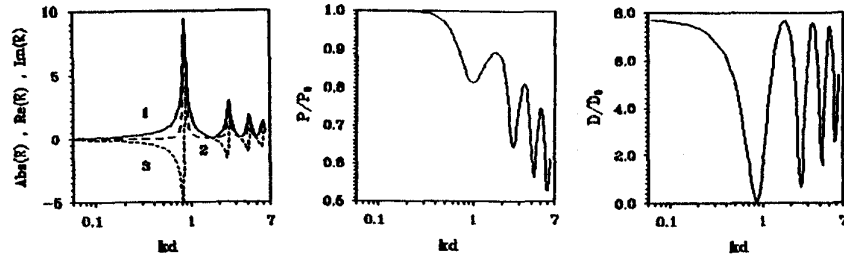


Fig. 3 Reflector's resistivity (a), total radiated power (b), and directivity (c) of antenna as functions of kd at $\epsilon = 3.45 + j0.25$.

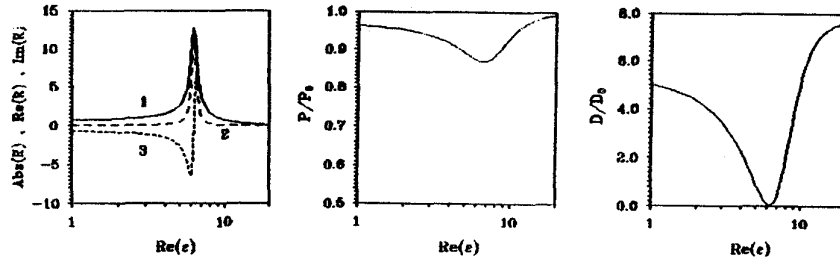


Fig. 4 The same as above versus the dielectric constant, for $d = 0.01a$, $Im(\epsilon) = 0.25$.

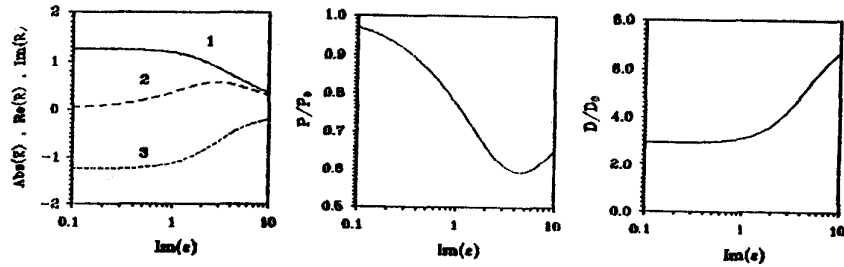


Fig. 5 The same as above versus loss factor, for $d = 0.01a$, $Re(\epsilon) = 3.45$. The radiated power and the directivity are normalized by the free-space-source counterpart values, $P_0 = 2024.15 \text{ Ohms}$, $D_0 = 6.50$.