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Effects of a fin edge close to a point caustic of a Gregorian antenna

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leads us to consider the influence of concrete age on the radiometric signals.

Figure 6 gives another type of result, namely, the radiometric signals in the case in which the medium is considered to be homogeneous. The more absorbent the medium, the weaker the signals collected.

It can be seen that an evolution of 3–12 years (i.e., a reduction of 0.5 in permittivity over the entire depth) corresponds to a small signal variation.

We think the dispersion of measurement data is the result of the ambient humidity that influences the first two centimeters of the concrete. In fact, hydration or dehydration phenomena in this layer change the relative permittivity considerably.

## 6. CONCLUSION

Microwave radiometry is a technique capable of distinguishing local thermal variations in concrete at thicknesses of the order of 10 cm, as a result of duct heating.

The feasibility study presented in this article examines a numerical model of this application, first in the case of constant permittivity and then considering the existence of a permittivity gradient within the concrete.

A better agreement between theory and experiment is observed when a permittivity gradient within the concrete is taken into account.

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# EFFECTS OF A FIN EDGE CLOSE TO A POINT CAUSTIC OF A GREGORIAN ANTENNA

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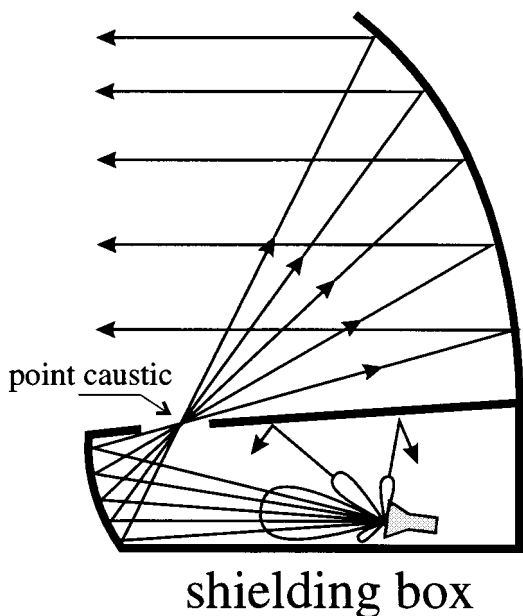
**ABSTRACT:** The problem of edge diffraction close to a point caustic is analyzed in a typical dual-reflector Gregorian antenna in offset configuration. The diffraction phenomenon is produced by a perfectly conducting fin located between the feeder and the main reflector. This fin is sometimes used to reduce the coupling between the primary feed and the main reflector. For the sake of simplicity, the two-dimensional case is studied here, but the present technique can also be applied to practical three-dimensional configurations. © 1997 John Wiley & Sons, Inc. *Microwave Opt Technol Lett* 14, 20–23, 1997.

**Key words:** edge diffraction; reflector antennas; antenna feeds

## 1. INTRODUCTION

High-gain reflector antennas for space applications sometimes require pressing performances of cross-polarization levels. Gregorian antennas in offset configuration are largely used in these applications, because they permit one to compensate for the deformation of the current lines on the main reflector, thus yielding excellent polarization purity [1]. Nevertheless, this performance can be deteriorated by undesired coupling mechanisms such as the direct illumination of the main reflector from the side lobes of the primary field. Vice versa, it may be desirable to minimize the coupling of the near field produced by the main reflector currents with the primary feeding structure. Indeed, because the feeder (i.e., a horn antenna) has a metallic structure essentially concentrated close to the subreflector focus, its scattering can produce a refocalization of rays through the dual reflector system; thus, cross-polarization level may increase.

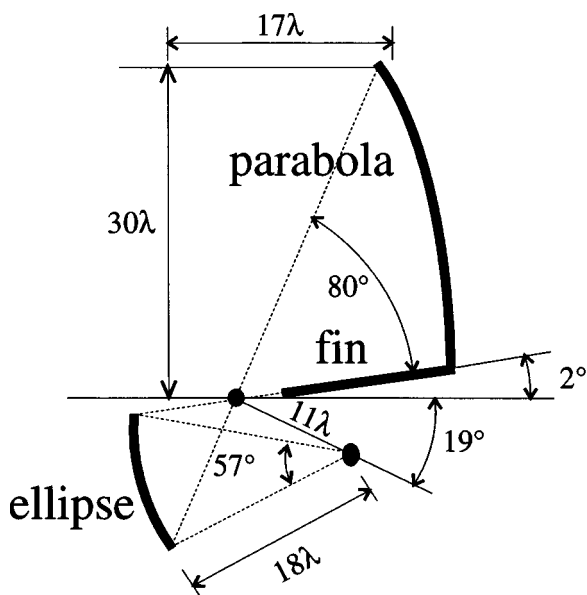
A simple way to obtain decoupling between the main reflector and the primary feed is that of enclosing the feed/subreflector system in a shielding box, which is entirely closed, except for an aperture around the point caustic. This arrangement, which is sketched in Figure 1, could also have the purpose of reducing spillover from the subreflector. Furthermore, it can be usefully employed in compact ranges to realize the ground of the anechoic chamber [2]. On the other hand, the presence of the shielding box originates two problems. First, the control of the illumination tapering of the subreflector becomes a difficult task, owing to the interaction between the subreflector and the box walls (e.g., multiple reflections). Next, in addition to the desired decoupling between primary feeder and main reflector, the above solution also creates undesired diffraction mechanisms at the aperture rim around the caustic, so that worsening of the cross-polarization performances may occur. Absorbers can be introduced inside the box to alleviate these problems. This method, often used in compact ranges, is unpractical for space antennas, owing to the subsequent loss of efficiency.



**Figure 1** Offset Gregorian antenna with shielding box for decoupling primary field and main reflector

An alternative, less perturbative shielding makes use of a separation fin placed between the feeder and the main reflector. This configuration is shown in Figure 2, where dimensions of a compact antenna for space applications are also indicated. Particular care should be taken to put the edge of the fin sufficiently far from the point caustic, to avoid spurious diffraction effects. In order to investigate the perturbation on the secondary field caused by the decoupling fin, two-dimensional geometry is analyzed in this article. This geometry consists of a half plane illuminated by a near point-caustic field, which is produced by an elliptic-shaped reflector.

Owing to its intrinsic limitation in describing caustic fields, neither geometrical optics (GO) nor geometrical theory of diffraction (GTD) can be applied to provide the incident field



**Figure 2** Geometry of a Gregorian antenna with a decoupling fin

at the fin edge. For example, GO would provide an infinite field at the point caustic and zero elsewhere. This could erroneously suggest, to improve decoupling, putting the fin edge close to the point caustic, without carefully considering the perturbation that it can produce on the secondary field. This purely optical view is obviously wrong. Actually, the field distribution is concentrated around the point caustic, and decreases away from it more or less rapidly, depending on the kind of illumination of the subreflector. Consequently, significant diffraction effects may also arise when the edge is not so close to the point caustic.

A more appropriate description of the field close to the point caustic is provided by a physical optics (PO) technique applied to the elliptic subreflector. In Section II, this field is defined on a convenient aperture plane passing through the point caustic and one subreflector edge. In the same section, the aperture field is calculated via PO in the absence of the fin; this may give rough information on the distance at which the decoupling fin can be inserted without introducing significant perturbations on the secondary field. In Section III, the diffracted field from the fin edge is obtained by applying the diffraction coefficients of the Uniform Theory of Diffraction (UTD) [3] to the field produced by each elementary PO contribution from the subreflector.

## 2. FIELD ON THE SUBREFLECTOR APERTURE PLANE

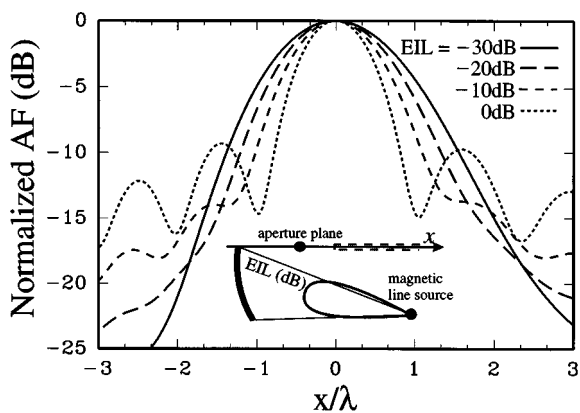
Let us define an aperture plane containing the upper edge of the subreflector and the point caustic. In the present case the fin is contained in the aperture plane (Figure 2), as may occur for the sake of convenience in the mechanical arrangement.

In this section the aperture field (AF) in the absence of the fin is calculated by applying PO to the subreflector. This may provide physical insight, because the width of the AF envelope gives us an idea of the extension of the caustic zone in which the presence of the fin edge can produce perturbation.

The subreflector is illuminated by a TE field produced by a focal magnetic source. A Gaussian-type pattern is attributed to this source, whose width is set in order to have the desired edge illumination level (EIL) of the subreflector. Actually, the two edges of the ellipse are illuminated at different levels. Indeed, in Gregorian offset configurations, obtaining symmetry in the main reflector illumination often requires pointing the primary beam away from the center of the subreflector. This produces asymmetry in the edge illumination of the elliptic subreflector. In the following, for the sake of simplicity, we will refer to the illumination level of the edge in the aperture plane. The other one is illuminated at a lower level.

Figure 3 shows the magnetic AF amplitude in a region close to the point caustic, obtained by applying PO to the subreflector. This normalized field is plotted for different EILs, from 0 dB (uniform illumination) to -30 dB with respect to the peak of the primary beam. The AF is obviously concentrated close to the point caustic, and its envelope decays with different slope, depending on the EIL. In particular, lower EIL produces a narrower width of the AF envelopes, as expected. Furthermore, nonoscillating behavior is obtained for low EILs; at variance, oscillations arise for increasing EIL, owing to the interference of the subreflector edges' diffraction contributions.

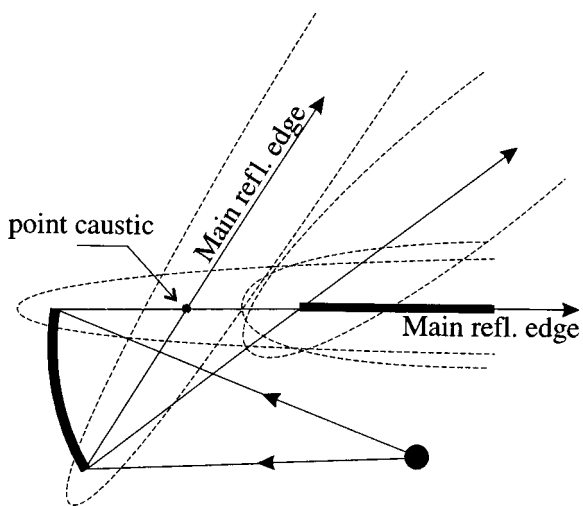
In the next section the influence of the shielding fin on the secondary pattern is investigated.



**Figure 3** Aperture field close to the point caustic for different edge illumination levels. The geometry is that defined in Figure 2

### 3. DIFFRACTION AT THE FIN EDGE

The fin has the aim of reducing the direct coupling between the primary field and the main reflector. Perturbation effects are expected when the fin edge is located too close to the point caustic, especially when the caustic region has a wide extension (Figure 3). UTD cannot be directly applied to define the incident field on the fin edge, because of its inherent limitation in describing caustic fields. Furthermore, when the fin edge is far from the point caustic, so that a ray description can be possible, difficulties arise in applying conventional UTD to the present double-diffraction problem. Indeed, as is well known [4–6], the subsequent application at the two edges of the ordinary UTD diffraction coefficients fails when the second edge is located in the transition region of the first one and the diffracted field is calculated close to the shadow or reflection boundaries of the second edge. For the geometry considered in the present case, the above critical situation occurs. Indeed, as sketched in Figure 4, the diffracted field from the upper edge of the ellipse illuminates the fin edge in the transition region of its pertinent reflection boundary, so that this region overlaps with that of the double-diffracted ray when observed at grazing. This observation aspect should be carefully considered in the total design, because it is close to the lower edge of the main reflector,



**Figure 4** Ray model and relevant transition regions (fin edge sufficiently far from the point caustic)

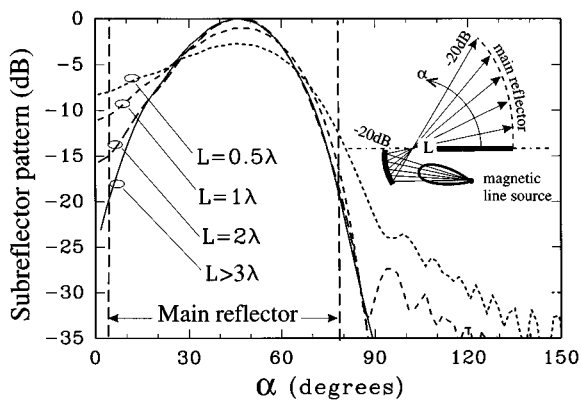
whose illumination level modifies the shaping of the main beam. At variance, the transition regions relevant to the lower edge of the ellipse are not aligned with each other, so that they do not overlap at the upper edge of the main reflector. This means that the presence of the fin affects the illumination level of the lower edge more than that of the upper one; indeed, the diffracted field in the transition region becomes of the same asymptotic order of the incident field. This has also been confirmed by the results presented below.

Although the mathematical description of the mechanism described above can be carried out by using a generalized Fresnel transition function [7–9], in the present case it is convenient to avoid the direct use of a ray technique because it does not provide a field description when the fin edge is too close to the point caustic. The problem has been formulated here by using a hybrid PO/UTD approach. In particular, the incident field on the edge is obtained as the sum of contributions that are produced by each PO elementary current on the elliptic subreflector. At variance with respect to the previous section, each current element radiates now in presence of the fin. This latter has been modeled by a half plane, so that its effect may be accounted for by using UTD. In particular, the total field from each elementary PO source is considered as the sum of the direct incident field in the nonshadowed region plus the field diffracted at the half plane. The total diffraction effect is reconstructed by integrating all the responses to the elementary incident PO fields.

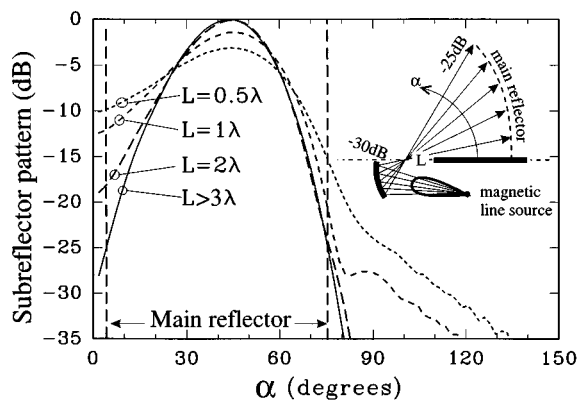
This method has been applied to the geometry shown in Figure 2, with two different EILs of the subreflector, namely,  $-20$  dB [Figure 5(a)] and  $-30$  dB [Figure 5(b)]. This ensures the upper edge of the parabola to be illuminated at  $-20$  dB [Figure 5(a)] and  $-25$  dB [Figure 5(b)], respectively, as depicted in the insets. The subreflector far-field patterns are plotted for four different distances of the edge from the point caustic, namely,  $L = 0.5\lambda$ ,  $1\lambda$ ,  $2\lambda$ , and  $L > 3\lambda$ , respectively. This latter case (continuous line), provides results that coincide with those in the absence of the fin (at least for levels above  $-35$  dB from the maximum). When the fin edge approaches the caustic, the maximum level of the secondary pattern decreases (e.g., 4 dB when  $L = 0.5\lambda$ ). Furthermore, the EILs of the main reflector dramatically increase, thus rendering the shaping of the main beam critical. In particular, the EIL that is more affected from the spurious diffraction effects is that adjacent to the fin. This behavior may be explained by referring to the ray model in Figure 4 when this model is still applicable (i.e., fin edge not too close to the point caustic).

### 4. CONCLUDING REMARKS

An analysis of the perturbation effects due to a separation fin placed between the primary feed and the main reflector is carried out for an offset Gregorian antenna. This fin has the aim of decoupling the primary field from the main reflector, thus improving the cross-polarization performances of the antenna. Although the two-dimensional analysis proposed here can give only qualitative information for a practical three-dimensional design, it is useful to provide insight into the physical diffraction mechanisms at the fin edge as well as to single out some precautions to be taken in the design. In particular, it is found that, when low edge illumination of the parabola is required, the edge of the fin should be precautionally located sufficiently far from the point caustic (more than  $3\lambda$ ).



(a)



(b)

**Figure 5** Secondary patterns for the geometry defined in Figure 2, for different distances between the fin edge and the point caustic. (a) Subreflector EIL = -20 dB, (b) subreflector EIL = -30 dB

It is worth noting that the same radiation integral of the present formulation can also be evaluated asymptotically. In this case, complex ray tracing may be conveniently used, when a Gaussian primary illumination is assumed. Alternatively, the multiple-Gaussian-beam decomposition technique described in [10] may be used, which permits us to avoid the definition of complex sources. These approaches, which overcome the difficulties of the caustic-field description, are presently under investigation.

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## AN OPTICALLY PREAMPLIFIED DIGITAL PPM RECEIVER WITH IMPROVED SUBOPTIMUM FILTERING

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**ABSTRACT:** Original analysis and results are given for an optically preamplified digital pulse-position-modulation (PPM) receiver with an improved electrical-domain filtering regime consisting of a matched filter cascaded with a pulse-shaping network. Impressive sensitivity results are reported, with the 21.54 photons/bit predicted at 622 Mbit/s, surpassing both an equivalent optically preamplified on-off keyed nonreturn-to-zero (OOK NRZ) system (by 8.1 dB) and the fundamental limit of such a preamplified OOK NRZ receiver. © 1997 John Wiley & Sons, Inc. *Microwave Opt Technol Lett* 14, 23-28, 1997.

**Key words:** optical-fiber communications; pulse-position modulation-optical preamplification

#### 1. INTRODUCTION

Digital pulse-position modulation (PPM) over the optical-fiber channel exchanges some of the abundant fiber bandwidth for impressive receiver sensitivity benefits, and thus has been studied widely in relation to different receiver configurations [1-5]. Because of the recent emergence of practical optical amplifiers, the present authors have studied a number of