Influence of Gaps Between Panels in Large Reflector Antennas — comparison of different techniques

Michael Lumholt
TICRA, Laederstraede 34, DK-1201 Copenhagen K, Denmark

1 Introduction

Earth station antennas are commonly manufactured from several panels, which typically are mounted with small inter-panel gaps in order to allow thermal expansion. The gaps will influence the radiation properties of the antenna, create unwanted sidelobes and, equally important, provide a path from the feeding system to the area behind the reflector. In a ground station application, this would mean that the feed would pick up noise from the generally warm earth behind the antenna and thus imply a reduction of the noise temperature.

Consequently, it is of substantial interest to be able to model the above effects in the design as well as synthesis of the antenna. The effects of the inter-panel gaps on the antenna radiation have been the subject of several studies reported in the literature, e.g. [1]–[3]. In a recent contract from the European Space Operation Centre (ESOC), TICRA has studied the methods reported in the literature [4]. It is found that none of the techniques are adequate to model all possible values of the gap width. However, using a narrow-gap approximation in combination with a wide-gap approximation, the entire range of gap widths can be covered with good accuracy. These two techniques have been implemented in TICRAs general antenna software package, GRASP.

In the present paper, the four most promising techniques for implementation in GRASP are compared. It is emphasized that all methods considered in the paper are restricted to analyze a gap in an infinitely thin screen. The thickness of the screen can be accounted for using mode-matching techniques or integral equation formulation.

2 The gap in an infinitely thin screen

As the inter-panel gaps on a large reflector are long in terms of wavelengths, a cylindrical, two-dimensional scattering problem can be used to model the influence of the gaps. Using the Babinet principle, the scattering from the gap of width $w$ is expressed in terms of the scattering from the infinite flat strip of the same width shown in Fig. 1. The strip is illuminated by a plane wave incident from the direction $(\theta_i, \phi_i)$. 

![Fig. 1 Scattering configuration.](image)
3 Narrow-gap techniques

The two narrow-gap approximations investigated are those reported in [1] and [2-3]. Both methods consider the plane-wave scattering by the gap. The work presented in [1] implements a power series expansion of the magnetic currents induced in a narrow gap. The work in [2-3] uses a series expansion of the scattered field from the narrow gap. The latter series converges for \(0.32 \lambda < w < 0.90 \lambda\), but diverges for wider gaps.

The scattered fields from the scattering configuration in Fig. 1 obtained by the two approximations as well as by an integral equation technique (IE/MoM) have been computed for various strip widths and incident angles, and the results are compared in [4]. The comparison for the strip width equal to a quarter of a wavelength, and the incident normal to the strip is shown in Fig. 2, with TM illumination (the E-field parallel to the edges of the strip) at the top and TE-illumination at the bottom.

It is observed that the method in [2-3] by Shore & Yaghjian provides an excellent approximation to the radiated field and is more accurate than the method in [1]. The same conclusion is true for all strip widths up till the above-mentioned limit of \(0.32 \lambda < w < 0.90 \lambda\).

4 Wide-gap techniques

Two wide-gap approximations are investigated, both of which are based on the principle of the physical optics (PO) and the physical theory of diffraction (PTD). Both approximations are expressed in terms of equivalent edge currents (EEC). One of the methods applies the so-called first-order PTD-EEC derived in [2], and the other method applies the second-order PTD-EEC derived in [5]. Results obtained by the two methods have been calculated for various strip widths and incident angles and compared to the IE/MoM results. The comparison for \(w = 2.5 \lambda\) and \(\phi^i = 60^\circ\) is shown in Fig. 3.
Both methods yield a good approximation to the scattered field. However, the result by first-order PTD-EEC becomes inaccurate in a region close to the plane of the strip. In general, the results for TM-illumination are more accurate than the corresponding results for TE-illumination.

In Fig. 4, the comparison is shown when the wide-gap approximations are used for strip widths as small as \( w = 0.3\lambda \). The second-order PTD-EEC provides surprisingly accurate results for such narrow strips.

### Summary

In summary, it has been found that the combination of the narrow-gap approximation in \([2-3]\) and the wide-gap approximation using second-order PTD-EECs covers the entire range of gap widths.

Hence, these two methods have been implemented in GRASP for the analysis of the inter-panel gap effect.

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