Analysis and Design of a High-Gain Folded Reflectarray with Curved Polarizer

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Folded reflectarrays were firstly introduced in (D. Pilz and W. Menzel, Electronics Letters, 34, 9, 832-833, 1998) as alternative solution to classical parabolic reflector antennas for obtaining high gain, low sidelobe levels, and low losses. In the recent years they have been used for obtaining pencil or shaped patterns (J. A. Zornoza et al., Trans. Antennas Propag., 54, 2, 510-518, 2006) in radar applications (I-Y. Tarn et al., Trans. Antennas Propag., 56, 6, 1510-1517, 2008), and both in ground segment and, more recently, in space segment communications (W. Menzel et al., Antennas Propag. Mag., 44, 3, 24-29, 2002; Q. Luo et al., Trans. Antennas Propag., 63, 4, 1365-1374, 2015).

The main advantage provided by folded reflectarrays is the reduction of the antenna dimensions (in depth) with respect to classical parabolic reflectors. Their basic operative principle can be summarized as follows: a wave with a linearly polarized field is radiated by the feed; a planar polarizing grid reflects the wave toward the reflectarray (Fig. 1a); there, each element of the reflectarray, that acts as a “polarization-twist reflector”, provides a prescribed phase shift and a 90° twisting of the polarization. The grid is now transparent for the reflected wave that is then radiated into free space.
The classical design strategy for a folded reflectarray is based on the analysis of periodic array elements normally illuminated by an incident plane wave. The optimum combination of reflection phase angles for the field components tangent to the reflectarray is then selected, according to both twisting and focusing requirements. This design procedure includes several approximations, which can lead to a suboptimal design when the wave illuminating the reflectarray presents a spherical spreading and cannot be considered normally incident (Fig. 1a). These aspects result into suboptimal tapering and spillover efficiencies of the reflectarray.

In this work we present a novel folded reflectarray solution in which the polarizing grid presents a spherical surface shape (Fig. 1b) that can be easily combined into the radome, while maintaining the compactness of the antenna. The design strategy is based on the use of geometrical optics for estimating the field reflected by the polarizer. When the curvature of the polarizer surface is properly designed, the rays illuminating the reflectarray present a nearly normal incidence. As consequence, an improvement of both tapering and spillover efficiencies can be reached. Furthermore, since now the feeder-polarizer-reflectarray paths experience almost the same length, the operating bandwidth is widen with respect to the classical planar polarizer solution. By using such strategy, a prototype is designed. The relevant electrical performances, along with the details of its design and analysis, will be presented during the conference.

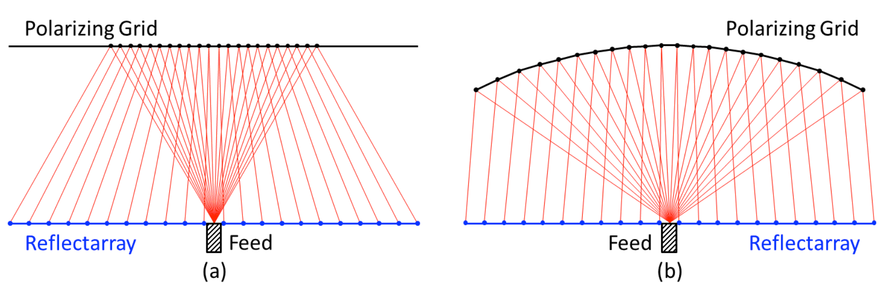

Figure 1. Folded reflectarray 2D geometry. The black line represents the polarizing grid, whereas the blue line represents the reflectarray. In red the ray paths of the field, radiated by the feeder and reflected by the polarizer, are depicted. (a) Classical geometry. (b) Novel proposed geometry.