Design Considerations for Splash Plate Reflector Antenna

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Abstract –**In this paper analysis and design of splashplate reflector antenna is given.Splashplate feed offers simplicity and cost-effective, easy-to-manufacture design which makes them a strong candidate for mass production of point-to-point antenna systems. Consecutivedesign steps are also proposed.**

Keywords –**Splashplate reflector antenna, Parabolic antenna, Splash plate**

I. Introduction

Recent evolution of broadband radio communications brought a need of various antenna designs, which combine high performance and cost effectiveness. Such antenna devices are parabolic antennas of different kinds, intended to cover ISM license free frequency bands. The basic design principles are explained in [2] and [3]. Despite the simplicity, in order to achieve maximum efficiency, a careful selection of dimensions and component parameters is necessary. The present paper discusses the features of such a selection.

II. Design Features

Parabolic splash plate antenna consists of parabolic reflector, splash plate and feed system (Fig.1). The reflector may follow strictly a paraboloidal shape or may depart from it in order to improve efficiency or side-lobe specifications [2]. Such setup forms 2 foci – in positive and negative direction from the splash plate, with focal distance (f1-f2). The feed phase centre aligns with the first focal point of the splash plate and the second focus of the splash plate – with the focal point of the main reflector. The size of the splash plate is determined by the cone encompassing the focal point of the main reflector and the main reflector rim [3]. However this rough recommendation is not always applicable, especially in cases when shallow reflectors are in place and the feed system has to be as simple as possible. The dielectric lens has two purposes. In one hand it supports the splash plate, on other hand it focuses the electromagnetic energy toward the plate and provides electrical match between the feed aperture and the free space. It also has an impact on scattered radiation from the plate toward the main reflector.

One of the major factors for the gain of developed antenna is the field distribution over the aperture. Usually in dual reflector setups there is an opportunity to vary with several geometrical features to control the field distribution. In the given setup they are: feed pattern, distance from the splash plate to main reflector vertex and the dielectric permittivity of the lens.

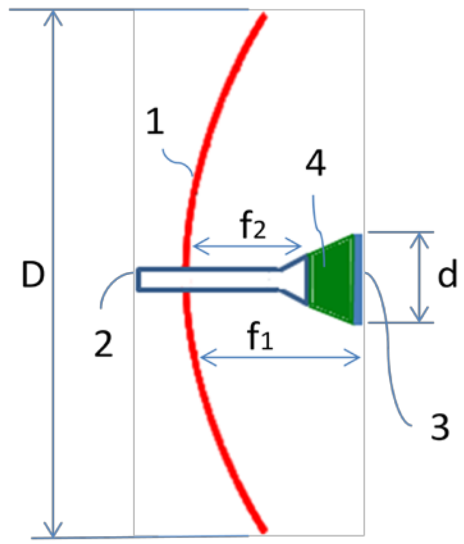

Fig. 1. Splash Plate Reflector Antenna. 1- reflector, 2 – feed system, 3-splash plate, 4 – dielectric lens

The last design consideration is the shape of the splash plate. For simplicity it can be a flat surface. However this shape may lead to increase of the feed return loss above acceptable limits.

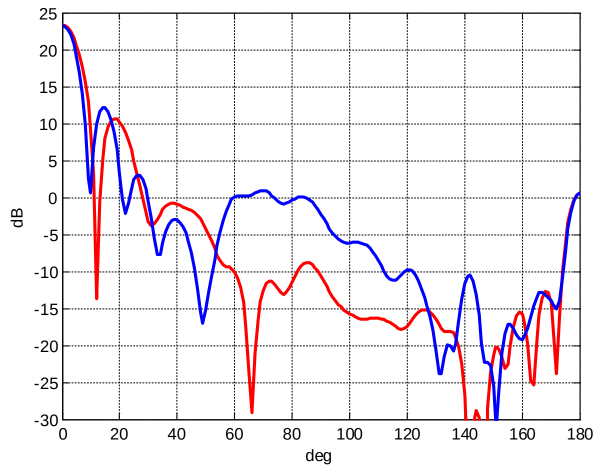

Fig. 2. Radiaton pattern of the proposed antenna (E-plane – red, H-plane - blue)

A quarter-wave bump may be added in order to keep the return loss in spec within the band of operation. This narrowband solution is proposed in [3]. Additional steps may be added that improves the bandwidth. In case the feed creates torroidal shape focal point a ring-focus splash plat may be used [1].

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III. RESULTS

With a given frequency band of 806.11a (5.1-5.8GHz) and main reflector diameter of 350mm a splash plate dual optics antenna was designed with polypropylene as lens material and splash plate size of 65mm. The metal portion of the feed is straight circular waveguide with diameter of 40mm. Dielectric lens protrudes waveguide in conical wedge to provide electrical match to the feed and expands beyond the waveguide edge to splash plate rim to provide support of the splash plate structure. Antenna pattern in both planes is displayed on Fig.2. Antenna midband gain is 23.3dBi, which results in efficiency of 52.6%. The value achieved is below the average for parabolic antennas, however with a given reflector size, the splash plate constrains a relatively large portion of antenna aperture and therefore limits the maximum antenna gain. This number is achieved after a careful optimization and the author believes that no better value is possible.

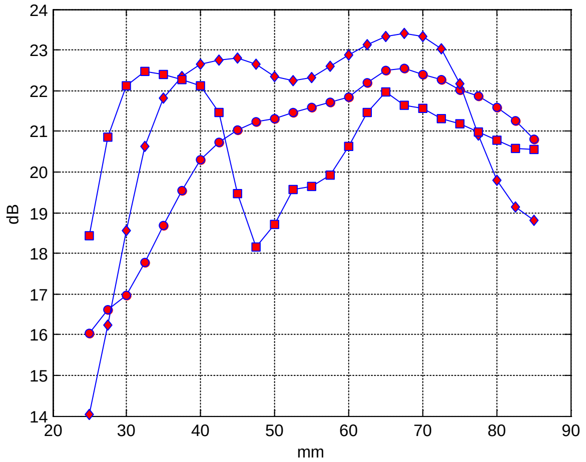

Fig. 3. Antenna gain vs. Splash Plate diameter with Lens dielectric permittivity as parameter (o – εr=1.5, ◊ – εr=2.2, □– εr=3)

A study was performed on antenna gain dependence of splash plate size with three dielectric materials (Fig.3). It shows that even small change in dielectric permittivity has a significant impact on antenna performance. A double peaked optimum has been noticed. In order to reduce the splash plate spill-over (energy leaking behind splash plate rim) and therefore antenna interference selectivity and immunity in forward direction, the larger of two optimal sizes was chosen.

Additional benefit of higher dielectric permittivity is noticed in cases when the splash plate is comparable with a free space wavelength. Augmenting the design with lens may improve the antenna gain. On Fig. 3 a study of antenna gain was conducted for 3 cases of lens material. The back side of the lens is used for splash plate support and determines it's size. With splash plate size of 30mm antenna delivers 17dB in case of εr=1.5 and 22 dB in case of εr=3 – almost equal to maximum achievable gain. If dielectric lens is removed, antenna will become completely inoperable, since the electromagnetic waves will diffract behind the splash plate instead of reflect.

As mentioned above the splash plate is chosen as a trade-off between feed pattern spillover and the main reflector size. In the present case, the feed radiating aperture is simple open-ended circular waveguide, selected for simplicity and cost efficiency. In order to improve the feed pattern and overall antenna cross-polarization performance, gain and return loss, additional measures can be taken as concentric feed chokes or even a use of corrugated horn for example. However the later designs will drive the cost of the feed above the limits placed for this particular design case.

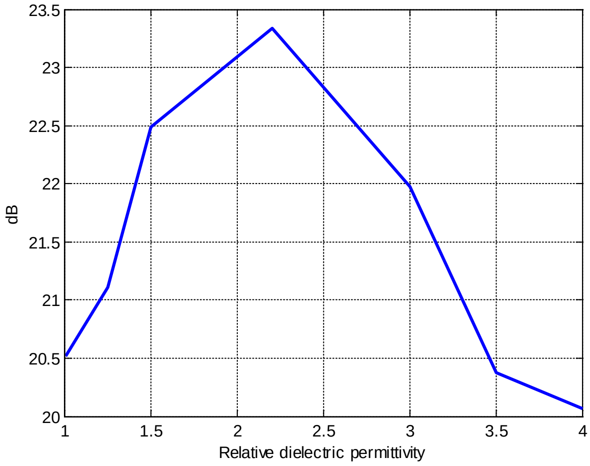

Fig. 4. Antenna gain vs. Lens dielectric permittivity;
Splash plate diameter fixed to the optimal value of 65mm

Considering the assumptions above additional research [Fig.4] was performed with different lens dielectric permmitivities and splash plate diameter fixed to the already delivered optimal size. It is obvious that the function has only one extreme and we can use the values delivered, to select the appropriate lens material.

This study confirmed the solution and prove that for given lens material there is only one optimal splash plate size, that exists.

As conclusion of analysis and results above, the proposal for design steps is:

-determination of the feed and feed pattern with a given reflector shape and size.

- determination of the optimal splash plate size.

- recursive optimization of the splash plate and selection of the dielectric lens material

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