Ka-band Dual Mode Circularly Polarized Reflectarray

Abdelhady Mahmoud
Department of Electrical and Computer Engineering
Concordia University
Montreal, Quebec, Canada
Abdelhad@encs.concordia.ca

Ahmed A. Kishk
Department of Electrical and Computer Engineering
Concordia University
Montreal, Quebec, Canada
kishk@encs.concordia.ca

Abstract—A double layers dual mode circularly polarized (CP) reflectarray antenna operating in the ka-band is presented. The reflectarray is center fed by a circularly polarized horn. The antenna is analyzed numerically. Angular rotation technique for a crossed slot array element is used to make phase compensation. An excellent CP performance is achieved with high aperture efficiency and wide band gain bandwidth of 16.5% for 1.5 dB gain variation.

Keywords—Reflectarray, Angular rotation technique, broadband circular polarization.

I. INTRODUCTION

Compactness and light weight are desired in satellite communications and radar applications. Downsizing of antennas and associated technologies have recently become a trend in the antenna community. The reflectarray is proposed to have a lower profile compared with the conventional reflector. In addition, space feeding eliminates the power division transmission lines used for conventional arrays [1].

In many cases, circularly polarization (CP) is chosen because of its robustness against environmental interference. Therefore, a variety of CP reflectarrays have been proposed in the literature using CP feeder [2]–[5]. Commonly employed elements are single-layer split circular ring elements [3], peripherally short-circuited circular discs [4], and the single-layer split square-ring elements [5]. One of the main shortcomings of these elements is narrowband CP. This narrow bandwidth imposes a very tight fabrication tolerance on the resonant frequency of the CP elements [3]. A broadband CP reflectarray of single-layer multiple-resonance structure can be found in [6].

Here, an angular rotation technique is used where, the CP characteristics are kept with a 2:1 linear relationship between reflected phase and rotated angle. The entire 360 degree of requested phase range can be achieved by simply rotating the element by 180 degree. Moreover, each element has the same dimensions and same resonant frequency. Improving the aperture efficiency in conjunction with broadband CP are satisfied using two layers with an interlaced ground plane having angular rotated cross-slot.

II. ELEMENT ANALYSIS AND DESIGN

The infinite array is illuminated by a Left-hand CP (LHCP) plane wave of normal incidence. The RHCP is considered as the co-polarized wave while the LHCP is cross-polarized. Cross-polarized suppression of more than 10 dB is obtained to assess the performance of the reflectarray within the desired band.

The proposed element is illustrated in Fig. 1, which compose of several layers attached to each other, but separated in the Figure for clarification. The element base size is 3.6 mm x 3.6 mm. The lower substrate is Duriod 5880 with \( \varepsilon_r = 2.2 \) and thickness 0.508 mm. The upper one is Duriod 6010 of \( \varepsilon_r = 10.2 \) and thickness 0.635 mm. There is an interlaced glue material of \( \varepsilon_r = 3.8 \) and thickness of 0.12 mm. A cross slot with tow unequal arms is etched on the ground plane and is interlaced between the two substrates. The \( L_1 \) length is chosen to resonate at the lower frequency and \( L_2 \) is resonating at the upper frequency. Then, the ratio between \( L_1 \) and \( L_2 \) are optimized to achieve best co-polarized and cross-polarized reflected wave. The cross slot with \( L_1 = 2.8 \) mm and \( L_2 = 1.82 \) mm is found to achieve the required specification. The perforation at the cell’s edges has a function of minimizing the coupling between adjacent cross slots. The co-polarized wave amplitude and phase for lower, upper and the center frequencies are illustrated in Fig.2.

The feed is a dual mode circular horn optimized for circular polarization at the desired band. There are two coaxial connectors, one for LHCP and the second for RHCP.

![Fig.1. CP reflectarray cell with rotated cross slot.](image-url)
There is a septum transformation sheet intermediated both ports for transforming linear polarization to circular polarization. The geometry details of the feed are shown in Fig. 3.

Based on the proposed element in Fig. 1, a reflectarray is designed. The cross slot is rotated according to their positions in the aperture. The array is constructed from 25 x 25 (625) elements of physical area 90 mm x 90 mm (9 λ_0 x 9 λ_0). The focal to distance ratio is determined related to the -10 dB amplitude edge tapering at 30 GHz. The focal distance is 60.5 mm from the surface of the reflectarray. Fig. 4 shows the far field radiation patterns in the X-Z and Y-Z plane, respectively. The side-lobe levels are below -17.5 dB in both planes, with cross-polarization level below -25 dB at boresight direction. The simulated axial ratio is 0.33 dB at 30 GHz with 3-dB axial ratio bandwidth from 26 GHz to 39.7 GHz as shown in Fig. 5. In addition, the simulated gain is illustrated in Fig. 5. The 28 dB gain is achieved at 30 GHz with 62.5 % aperture efficiency. The 1.5-dB gain bandwidth is 16.5 %.

III. CONCLUSION

A new CP reflectarray was presented using angular rotation technique. The reflectarray was a low profile with wide band axial ratio and 62.5 % aperture efficiency at 30 GHz.

REFERENCES