New Scanning-Spot Beam Reflectarray Antenna Design

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***Abstract*—In this report, a new design for a reflectarray antenna using mirror configuration will be proposed. By adapting to the two characteristics of a reflectarray antenna that changes beam directions using frequency and polarization, it is possible to realize a multi-scanning beam whose performance is as good as a conventional multi-spot beam with one reflecting mirror. Herein, we examine a scanning-spot beam that changes the beam direction by using frequency in the elevation direction and polarization in the azimuth direction in the Ka band. As a result, the proposed design efficiently covered the desired service area.**

Keywords—reflectarray, scanning spot beam, polarization, frequency

I. INTRODUCTION

According to research, in a multi-beam communication system using reflectarray antennas, covering a service area using a few mirror planes can be realized by changing the beam direction according to the polarization and frequency [1][2][3][4]. In this paper, a new reflectarray design using a mirror configuration and a linear element is proposed to change the beam direction.

II. DESIGN REFLECTARRAY

As shown in Fig. 1, a linear element is used to change the phase according to the polarization of the reflectarray [5]. The parameters of the elements are shown in Table Ⅰ.

Fig. 2 demonstrates the mirror configuration, and Table Ⅱ list the specification. The five primary radiators were placed in a way that beams of frequencies f_L and f_H are located 1 beam width away from the beam at the center frequency f_0. Radiators 1 and 3 were located +2 beam widths and -2 beam widths away from the center respectively, in the elevation direction while Radiator 2 was located at the center. Radiator 4 was +0.87 and +0.5 beam widths away from the center in the azimuth and elevation directions, respectively, whereas Radiator 5 was +0.87 and -0.5 beam widths away from the center in the azimuth and elevation directions, respectively.

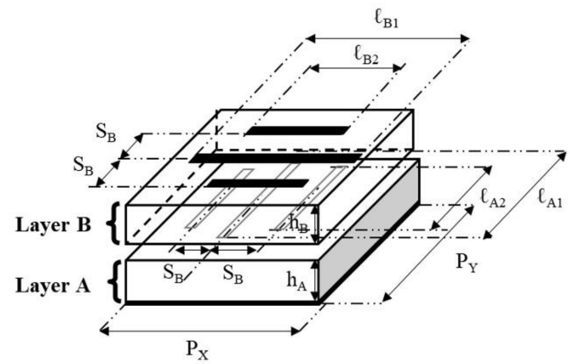

Fig. 1. Element shape

TABLE I ELEMENT DESIGN PARAMETERS

Thickness h_A, h_B	$0.15\lambda_0$, $0.02\lambda_0$
Dielectric constant ε_r	2.56, 2.59
tanδ	0.0015, 0.0017
Line width w	$0.02\lambda_0$
Element length l_A, l_B	$0.01\sim0.79\lambda_0$, $0.01\sim0.84\lambda_0$
Element spasing P_x=P_y	$0.38\lambda_0$

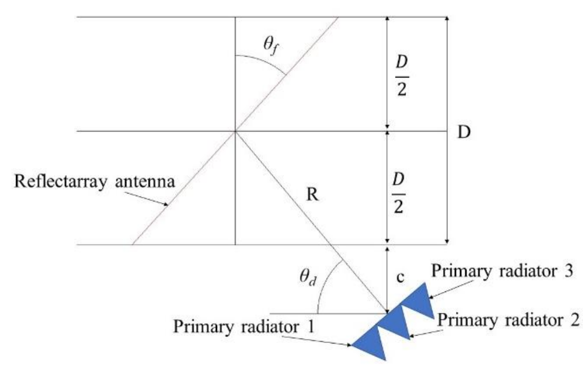

Fig. 2. Mirror configuration

TABLE II MIRROR SURFACE DESIGN PARAMETERS

Tilt angle θ_f [deg]	42.14
Horn angle θ_d [deg]	50
Beam direction [deg]	±0.65
Diameter of opening surface D	$41.2\lambda_0$
Distance from primary radiator to the center of aperture R	$43.13\lambda_0$
Clearance c	$12.43\lambda_0$
Frequency f_L	$0.96 f_0$
Frequency f_H	$1.04 f_0$

III. ANALYSIS RESULT

Based on the design parameters, an analysis was performed using the aperture distribution method. The resonant element used in the design was assumed to be an ideal element with no frequency characteristics. Fig. 3 and Fig. 4 show the analysis results of the V-pol and H-pol in the elevation cut, respectively. It can be verified that the f_L beam of Horn 1 and f_H beam of Horn 2 overlap ±1 beam width away from the f_0 beam. Similarly, the f_L beam of Horn 2 and f_H beam of Horn 3 overlap ±1 beam widths away from the f_0 beam. As seen in Fig. 5, the analysis results at frequency f_0 in the azimuth cut confirm that the vertical and horizontal polarizations (V-pol and H-pol) emitted the beams in the directions of -0.65 and +0.65 degrees, respectively. Fig. 6 shows the 35 dBi contour map for three frequencies and two polarizations at each of the five horns. As a result, it can be seen that a single reflectarray can efficiently cover the desired service area.

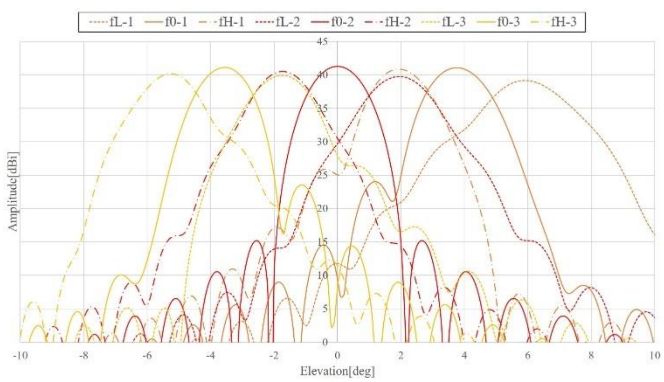

Fig. 3. Radiation pattern of V polarization (Elevation cut)

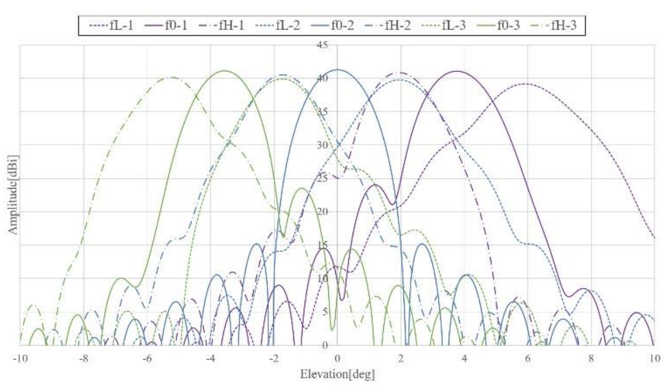

Fig. 4. Radiation pattern of H polarization (Elevation cut)

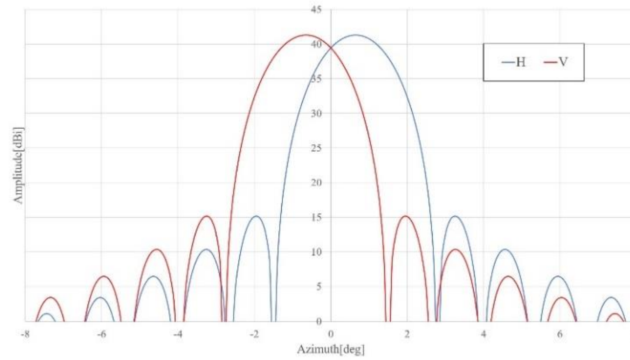

Fig. 5. Radiation pattern of f_0 (Azimurth cut)

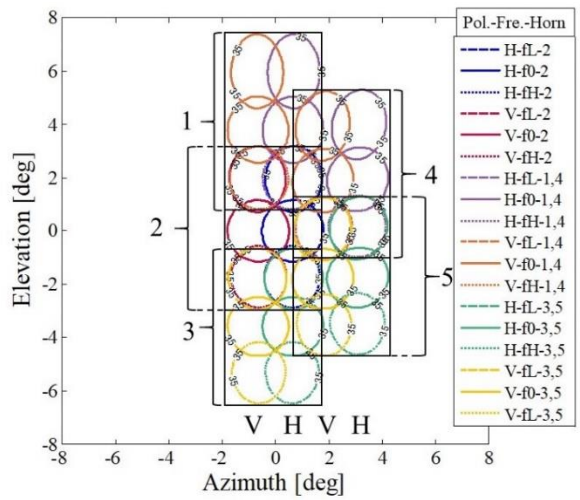

Fig. 6. 35dBi contour map

IV. CONCLUSION

The results show that the beam direction varies depending on the polarization and frequency of the reflectarray, which was the aim of this study. We will also fabricate a reflectarry based on the design parameters of our study and further examine its validity of the design.

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