Suppress Side Lobe Level of a Parabolic Antenna Using Disc Shaped Elements

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Abstract

Controlling and suppressing sidelobe level of a symmetric parabolic antenna is presented. This sidelobe suppression is done by adding three disc-shaped elements on the surface of the parabolic antenna. By adjusting the position and height of these elements, the surface of the side lobe is changed. With this method, the antenna is designed in the X-Band so that the output of the radiation pattern is such that the level of the first side lobe is relatively lower than the other side lobe. Also, the VSWR for the antenna is designed across the frequency range below 1.82. The simulations show that the level of the first side lobe on the right side of the antenna radiation pattern is reduced by 18dB compared with the simple reflex antenna with similar dimensions and specifications, and the VSWR in the frequency range (11.5GHz-12.5GHz) between $1.1 <$ VSWR < 1.82 .

Keywords: Parabolic Antenna, Sidelobe, VSWR, Radiation Pattern

1. INTRODUCTION

Reducing the antenna's sidelobe is always an important goal in design. Parabolic reflectors are one of the most desirable antennas in satellite and radar applications due to the high gain and the ability to transmit low-power data. One of the drawbacks to this kind of antennas is the relatively high level of side-effecting side lobe, which makes it difficult to use these antennas in satellite and radar systems, which causes inaccuracy in tracking and announcing the position of the target. However, in radar systems, the lower level of the lower side lobe, the lower the unwanted signals and the better detection of targets [1]. In satellite applications, horn of increase the antenna gain and also horn shadow in parabolic antenna. This displacement increases the level of the

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antennas. Reference [2] has been used to compensate for this problem and to reduce side lobe from strips with scattering material and 10bB sub-side lobe. In [3], by making changes on the surface of the reflector and adding a diffuse parabolic reflector, the size of 8dB has decreased from the lower side lobe. In [4], the design and synthesis of a parabolic antenna with a low sub-petal surface has been proposed using the reflector's resistive surface. For the first time, Danial Jacavanco [5], by providing a method using two similar discs on the reflector surface, managed to reduce 5dB from the surface of the first petal, using this method to create nulls in the antenna.

In this paper, we will show that by applying three discs on the surface of the reflector, the level of the first petal of the radiation pattern can be significantly reduced (about 18dB). By using this method, two discs, one with another piston ad-

justable height, are considered on the X-band reflector, which improves the VSWR, in addition to rear-side side lobe. The simulation results of the antenna are compared with and without control discs.

2. ANTENNA STRUCTURE

A. Design and Simulation of Parabolic Reflector Antenna (without Disc)

As a starting point, we design and analyze an optimal parabolic antenna model in the frequency range (11.5 GHz-12.5 GHz) with a central frequency of 12 GHz. For the design of the antenna, the horn WR90 X-Band is used which has dimensions a = 22.6mm and b = 10.16mm. The wavelength of the central frequency is $\lambda_0 = c / f_0$ = 2.5cm, so that the height of the edge (c) of the waveguide is considered to be arbitrary $2\lambda_0$ = 5cm. Assuming that the antenna required for this antenna is 31dB, the dimensions of the waveguide crater and the height of the pyramid are calculated from the relations (1) - (8), reference [6]:

$$X = \frac{G}{2\pi\sqrt{2\pi}} \tag{1}$$

The parameter G is the numerical value of the antenna, which is used to calculate the pyramid antenna, which is equal to 14dB = 10 LogG → G = $10^{1.4}$ = 25.118

$$\rho_e = (X).(\lambda) = 3.97 \text{ cm} \tag{2}$$

$$p_h = \left(\frac{X}{\lambda}\right). (G^2/6\pi^3) \tag{3}$$

By obtaining the parameters ρe and ρh, the dimensions of the pyramid span of the horn are as follows:

$$a_1 = \sqrt{(3\lambda)\,(\rho h)} = 6.32 \text{ cm} \tag{4}$$
$$b_1 = \sqrt{(2\lambda)\,(\rho e)} = 4.45 \text{ cm} \tag{5}$$

Also, the value of $c_1 = \lambda = 2.5$ cm. Therefore, using the calculated parameters, the reflector diameter can be calculated.

$$P_e = (b_1 - b)[(\rho e / b_1)2 - 0.25]0.5 = 2.53 \text{ cm} \tag{6}$$

$$P_h = (a_1 - a)[(\rho e / a_1)2 - 0.25]0.5 = 2.6 \text{ cm} \tag{7}$$

$$d = \frac{\lambda}{\pi}\sqrt{\frac{G}{\eta}} \approx 42.6 \tag{8}$$

The parameter η is the antenna efficiency and is considered in parabolic antenna between 55% and 70%, which is calculated in this paper with a value of 55%. The next step in designing is to place the horn at the focal length of the reflector, since the center of the phase is in the pyramidal antennas between the vertices and the pyramid openings. In an optimal model, horn to the reflector is 19.9mm. The software output of the radiation pattern of this antenna is in Fig(1).

B. Design and Simulation of Parabolic antenna with Disc-Shaped Elements

According to the previous statements, the goal is to suppress the first petal of the radiation pattern by adding elements on the antenna. The presence of these disc-shaped elements shown in Fig. 2 improves the pattern of antenna radiation. The discs are held at the front of the reflex reflector with 2 mm diameter retaining bars, the angles of the bars at the point of attachment to the reflector are perpendicular to the reflector surface (perpendicular to the tangential plane of the reflector at the contact point).

The P-disc has a radius of 1.389cm and the center of its distance from the reflex center of 1.389cm. The K and K' disc also have a radius of
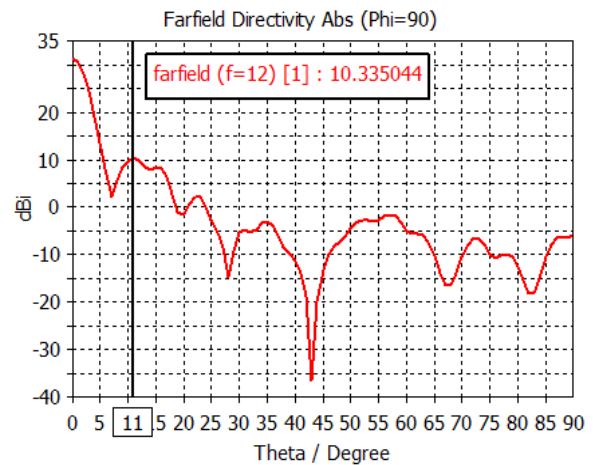

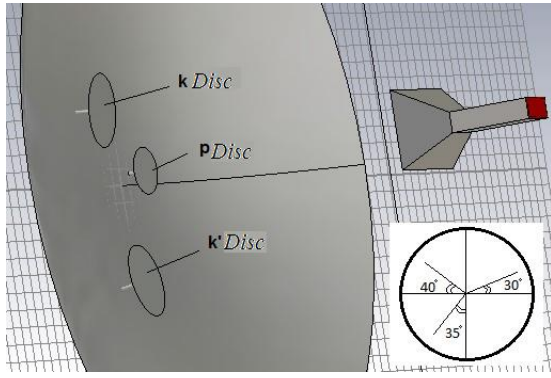**Fig. 1. Antenna Pattern without disks.**

Fig. 2. Disks position on the parabolic reflector antenna .

2.164cm, centered at 6.762cm from the center of the reflector. The thickness of all three discs is 1mm. The position of the disc bars on the reflector is shown in Fig. 2. The rod connected to the P-disc has a height of 1cm and the bars connected to the K and K' discs have a height of 1.5cm from the reflector surface. In the design, the height of the K and P discs and the height of the K' disc are varied by the piston box embedded behind the reflector, increasing the height of the K'K disc in the most of the reflex surface to 1.8 cm.

3. RESULTS AND DISCUSSIONS

The radiation pattern analysis and the VSWR of this antenna are performed in four modes where the K' disc is located at 1.5cm, 1.6cm, 1.7cm and 1.8cm. Figure (3) shows the radiation pattern of the antenna when the disc K' is from 1.5cm to 1.8cm.

Compared to the original antenna pattern, the radiation pattern of the antenna and the radiation pattern of the new antenna are reduced to about 10dB when the disc is located at a height of 1.5cm above the reflector surface, with the lower petal at 11dB. By increasing the height of the disc to 1.6cm, the side lobe low level at this angle is lower than the previous one, reaching 13.2dB. Also, at 1.7cm, this amount is reduced to 16.8dB, and finally, by placing the disc at 1.8cm height, the most decreases in the size of suppress side lobe level occurs, which is approximately 18dB. In contrast, the gain for the new antenna has been reduced by about 0.5dB compared to the antenna, which can be ignored in the case of 18dB reduction in the lower side lobe.

Fig. 4 shows the VSWR obtained for the initial antenna (without a disc) and the new antenna, which discs K 'at an elevation of 1.8cm. By increasing the disc's height, the VSWR chart is converted to a more favorable position, and the graph level is best placed within the 1.1 <VSWR <1.82 range.

4. CONCLUSION

The purpose of this paper was to design and simulate a parabolic antenna in the frequency range (11.5GHz-12.5GHz) in which circular and disc-shaped elements were embedded on the reflector surface. The presence of these disc-shaped
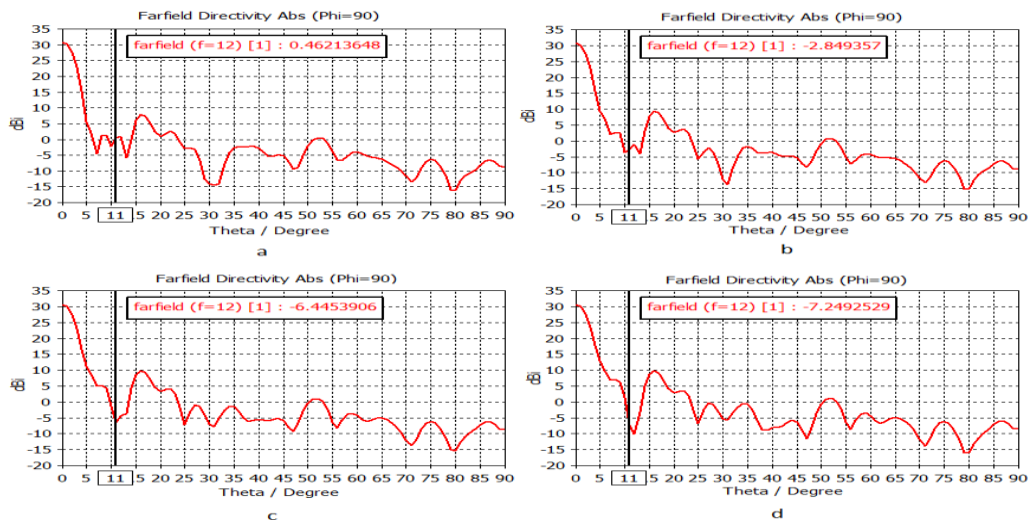

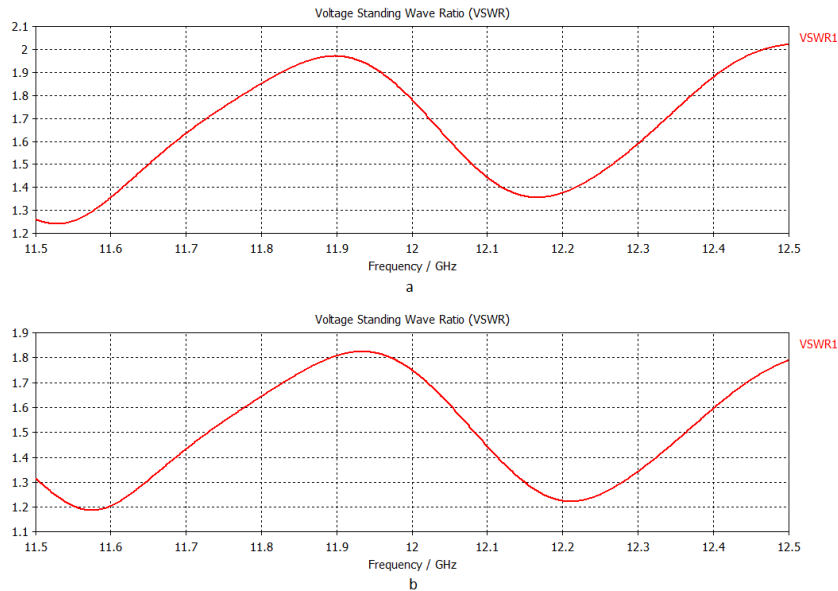*Fig. 3. Antenna pattern with three disks when height of K' disk is a) 1.5cm b) 1.6cm c) 1.7cm and d) 1.8cm .*

Fig. 4. VSWR a) without disk and b) with disk at 1.8 cm.

elements and their height adjustment from the surface of the reflector lead to a decrease of 18 dB to the first side of the petal in the antenna radiation pattern at an angle of θ = 11˚. Also, the VSWR for the desired antenna is good for a parabolic antenna without a disc. This improvement in the antenna's radiation pattern was achieved gain the loss of 0.5dB from the antenna, which can be neglected relative to the sub-netting of the antenna.

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