Analysis Design of Broad-Beam MSA Array Using Cavity Back Slot-Coupling

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1. Introduction

The antennas technology for space and Geographical Information System (GIS), especially, Low-Earth Orbit (LEO) satellite communication systems have been popularly to investigate. The parabolic reflector antenna is the most widely used in satellite communication due to high gain and narrow-beam. However, the feed horn and their arm are placed at the front of the reflector causing obstruct the aperture and its efficiency is degraded, while the large curvature is generally affected to the aerodynamic of the satellite when launching into the orbit. To solve these problems the novel type of the microstrip array is designed [1, 2]. Essentially, this microstrip array has no limitation in its dimensions and has much less distortion in its planar shape. This operation is similar to the parabolic reflector that naturally forms a planar phase front when a feed is placed at its focus. The advantaged of the microstrip array are low cost, small size, light weight and easy installation.

Since LEO satellite moves in very high-speed, therefore, time required for an earth station communicates with satellite is limited. The important techniques for overcoming these limitations, shaped reflector antenna [3], and microstrip reflectarray [4, 5] which are duplicated the same radiating aperture as parabolic backscatters were designed. Nevertheless, the shaped reflector and reflectarray antennas are used the feed horn place at the front of the reflector causing obstruct the aperture, and its efficiency is degraded.

In this paper, we propose an analysis design of broad-beam microstrip antenna (MSA) array using cavity-back slot-coupling. This structure is excited by a linear electric probe that is located at the center of inner surface of the rectangular cavity [6, 7]. To achieve broad-beam antenna, phase of each array element in the microstrip array antenna is specific designed to emulate the curvature of the parabolic backscatter function by adjusting the distance between microstrip arrays. Finally, the results of the return loss (S_{11}) and radiation pattern of the proposed antenna have been simulated by using antenna analysis software CST-Microwave studio. Simulations results are giving to verify present our described.

2. Antenna Design

The antenna parameters and location have been optimized using CST-Microwave studio simulation to achieve the best return loss and broad-beam radiation. The geometry of 5x5 microstrip antenna array using cavity-back slot-coupling is shown in Fig. 1. The dimensions of the broad-beam configuration have been designed for the operation frequency 10 GHz. The square shaped microstrip arrays of the optimal designed are etched on the Taconic substrate of thickness d = 0.767 mm and relative permittivity ε_r = 2.33. Fig. 2 illustrates the return loss for patches size variation. The minimum return loss of the operation frequency is occurred at -30 dB when the dimensions of a square patch has length l_p = 8.2 mm. The rectangular slot is etched in the center of ground plane, and mounted on the upper side of the cavity. The slot itself must not resonate over the operating frequency band of the antenna because this was produce radiation interfere with the radiation from the patch, thus it has length l_s= 5.2 mm and width w_s = 0.5 mm. The dimensions and location of the rectangular cavity are an important parameter to be considered in the antenna design. The dimensions of the rectangular cavity were designed and simulated by using CST-microwave studio. To realize the resonant frequency at 10 GHz, thus the dimensions of the cavity are length c_x = 20.9 mm, width c_y = 20.9 mm and height c_z = 5 mm. The cavity location to achieve the best return loss is appeared at dy = 10 mm shift from the center of slot along y- axis as shown in Fig. 3. The cavity was center fed with a linear electric probe of length l_f = 1.5 mm.

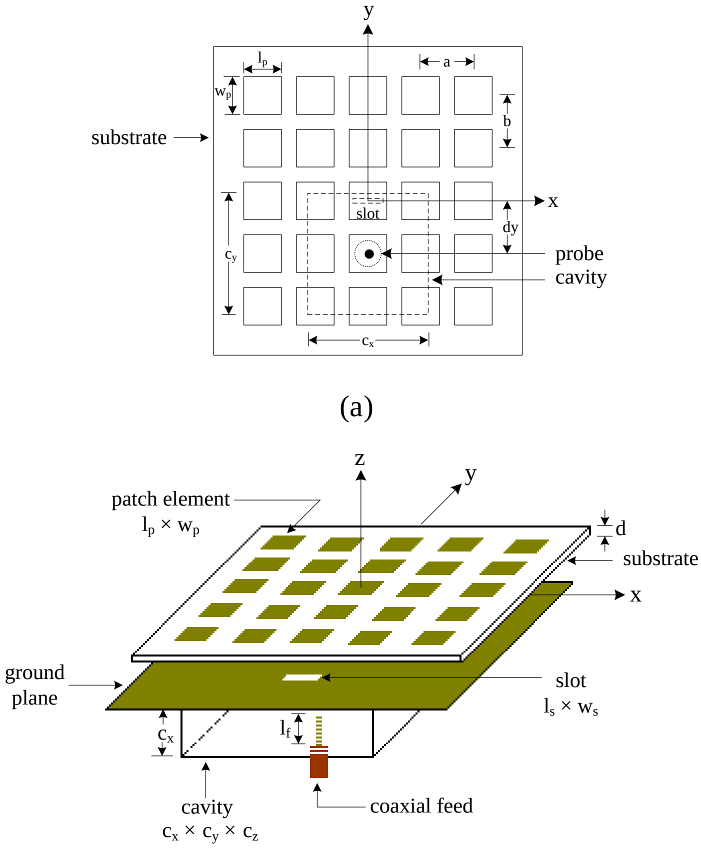


Figure 1: Geometry of the proposed antenna (a) top view and (b) perspective view, where l_P = 8.2 mm w_P = 8.2 mm, l_S = 5.2 mm,w_S = 0.5 mm, $c_X = c_Y$ =21.9 mm, c_Z = 5 mm, l_f = 1.5 mm, a = b = $0.34\lambda_0$

In order to achieve a broad-beam radiation and minimum return loss the spacing between microstrip array are varied from $0.3\lambda_0$ to $0.4\lambda_0$. The radiation pattern is shown in Fig. 4. The frequencies of the minimum return loss for different spacing between microstrip array are slightly different. The best return loss is occurred at -50 dB when the spacing between microstrip array is a = b = $0.38\lambda_0$.

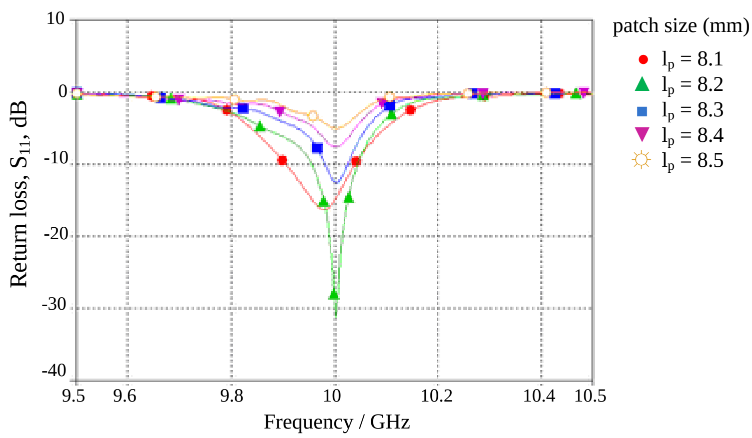


Figure 2: Computed return loss (S_{11}) of the proposed antenna by various the microstrip patch size.

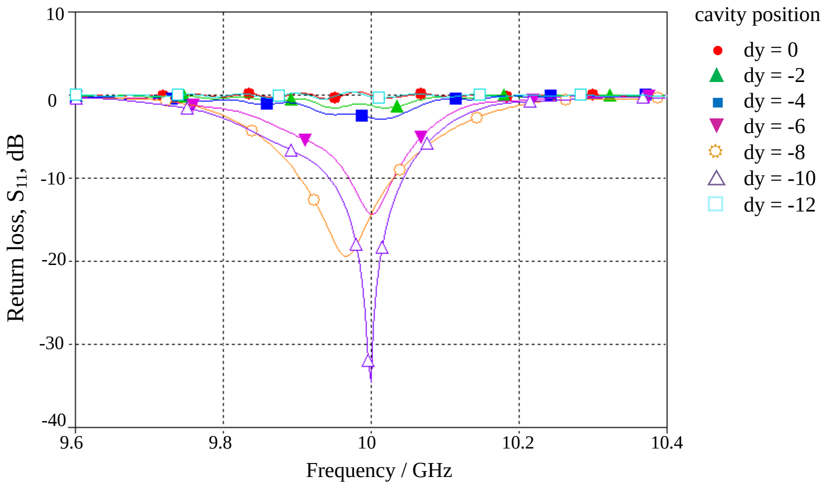
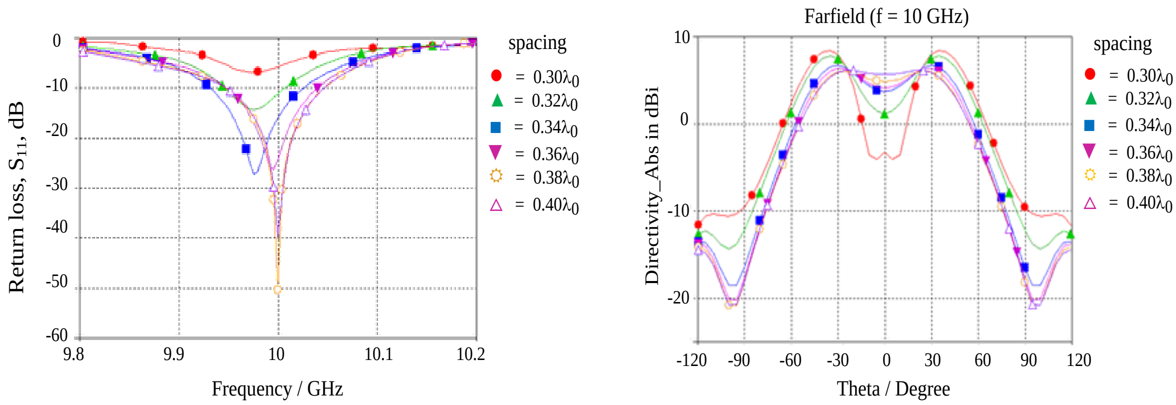


Figure 3: Computed return loss (S_{11}) of the proposed antenna by various the cavity positions along y-axis.

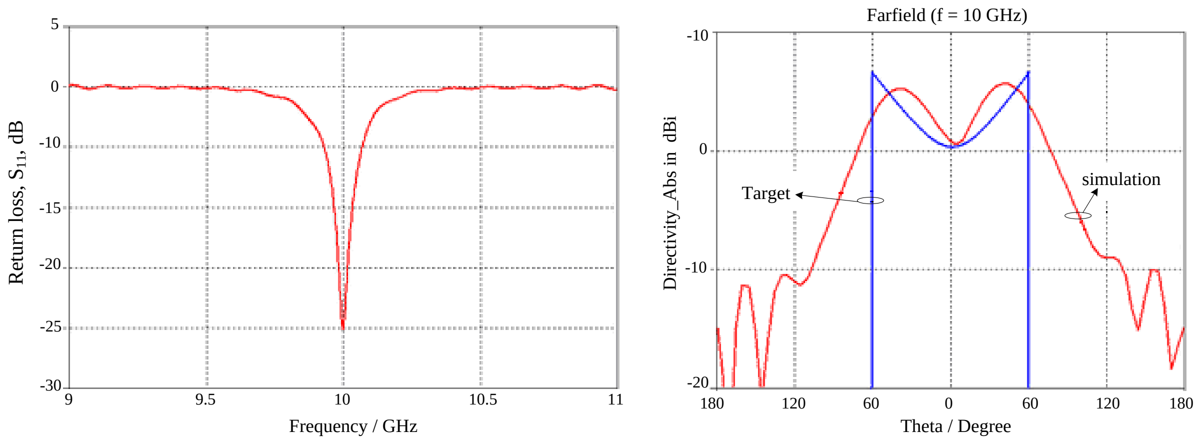


(a) (b)

Figure 4: Simulation results of the proposed antenna: (a) return loss (S_{11}) by various the cavity positions along y-axis, (b) radiation pattern of the proposed antenna by various the spacing between microstrip arrays ($a = b = n\lambda_0$).

3. Results

Computed the return loss and radiation pattern of the proposed antenna compare with the target of parabolic backscatter function in cartesian coordinate with the parameters as shown in Fig. 1, are illustrated in Fig. 5. It is evident that the broad-beam pattern is achieved. The return loss of the operating frequency 10 GHz is – 25 dB and -3-dB beamwidth (HPBW) of radiation pattern is about 100°. The bandwidth is determined at the value of return loss with no more than -10 dB respect to the minimum return loss at the operation frequency is about 100 MHz. The maximum gain of this proposed antenna is 5.7 dBi.



(a) (b)

Figure 5: Simulation results of the proposed antenna: (a) return loss (S_{11}), (b) radiation pattern at 10 GHz of the proposed antenna compare with parabolic backscatter function in cartesian coordinate.

4. Conclusion

In this paper, CST-Microwave studio was used for simulation of the broad-beam microstrip antenna array using cavity back slot-coupling. The simulation showed that almost the design of radiation pattern and the best return loss have been achieved. The proposed antenna has proven a better radiation pattern and gain comparing to the parabolic backscatter function design in the operation frequency at 10 GHz. The broad-beam microstrip antenna array that can be achieved by adjusting the spacing between microstrip array. Finally, the proposed antenna will be realized and experimented to validate the technique

Acknowledgement

The first author would like to thank the head of telecommunication group at the school of telecommunication engineering for his kind support and hosting of my research.

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