ANALYSIS OF A DIHEDRAL CORNER REFLECTOR ANTENNA EXCITED BY A PROBE INSIDE RECTANGULAR RING

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1. Introduction

At present, point to point communications has extensively and continuously received an attention for several decades. The antenna that can useful for the point to point communication is the antenna radiating unidirectional beam pattern. There have been the developments of these antenna types in literature [1]. The unidirectional beam antenna can be achieved by using some types of antenna structures such as microstrip antenna operating at fundamental modes [2], horn antenna [3], reflector antenna [4] and many others. In addition, the unidirectional beam can be obtained by using some specific antenna that is arranged to form the array configuration [5]-[6]. One alternative way is carried out by placing the antenna near a variety of reflector configuration [7]. However, each antenna belongs to its own merit and demerit. This paper proposes to accomplish the unidirectional beam by using the probe inside rectangular ring feed the dihedral corner reflector. The advantage of this structure is that it is simple and easy to fabricate. In addition, since there is no dielectric component, it has low loss. The antenna can be made by using low cost material that is easy to find in the market. Hence, this structure expects to possess cost effective [8]. The radiation characteristics of this proposed structure are compared among the included angles of 30°, 45°, 60° and 90° of the dihedral corner reflector. The radiation characteristics such as the radiation pattern, elevational and azimuthal beam peak in E-plane and H-plane, beamwidth and maximum directivity are investigated. The optimum spacing between the probe inside rectangular ring and the corner reflector that provides the maximum directivity is clarified. The result of the analysis is very useful for designing the high directivity unidirectional beam antenna.

2. Antenna structure

The structure of a probe inside rectangular ring feed the corner reflector is composed of the probe of length l_p aligned in z direction and it is protuded inside the the rectangular ring of the width a and the height b and the length c. The dimension of the ring is reasonably chosen to perform the dominant mode propagation inside the rectangular waveguide. Hence, the optimum value of the probe length, ring width, ring height and ring length are 0.25λ ,0.69λ,0.35λ and 0.25λ, respectively [8]. This structure radiates the bidirectional beam with the half power beamwidth in E-plane and H-plane of 84° and 58°, respectively. The maximum directivity is *6.33* dBi. Furthermore, the directivity can be further increased by forming this structure to feed the dihedral corner reflector at the spacing of s. The aperture size of the dihedral corner reflector is D_a, the length of corner reflector is l_c, the height of corner reflector is h and the included angle of corner reflector is α. Fig.1 shows the antenna geometry. The spacing between the probe inside rectangular ring and the vertex of corner reflector should be optimized. Moreover, the comparison among the radiation characteristics of the dihedral corner reflector for various included angles of 30°, 45°, 60° and 90° are given in the next section.

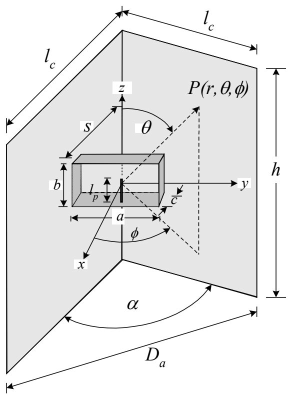

Fig. 1 Antenna structure.

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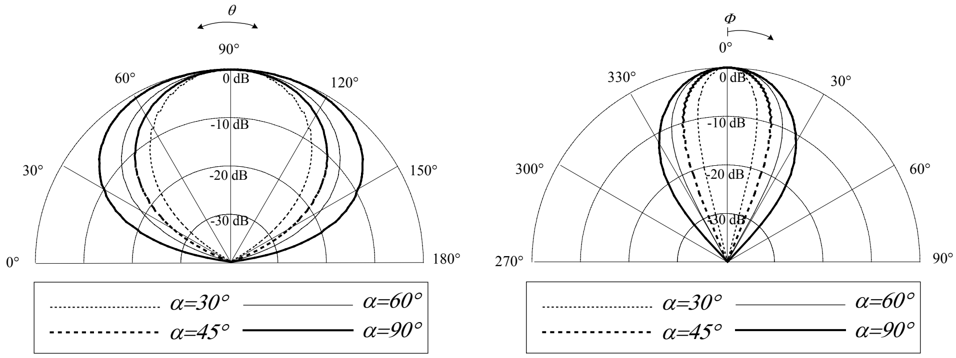
3.radiation characteristics

In this section, the analysis of radiation characteristics of the antenna for various the spacing between the antenna and the vertex of the dihedral corner reflector such as radiation pattern, elevational and azimuthal beam peak in E-plane and H-plane, beamwidth and maximum directivity are shown.

3.1 Radiation pattern



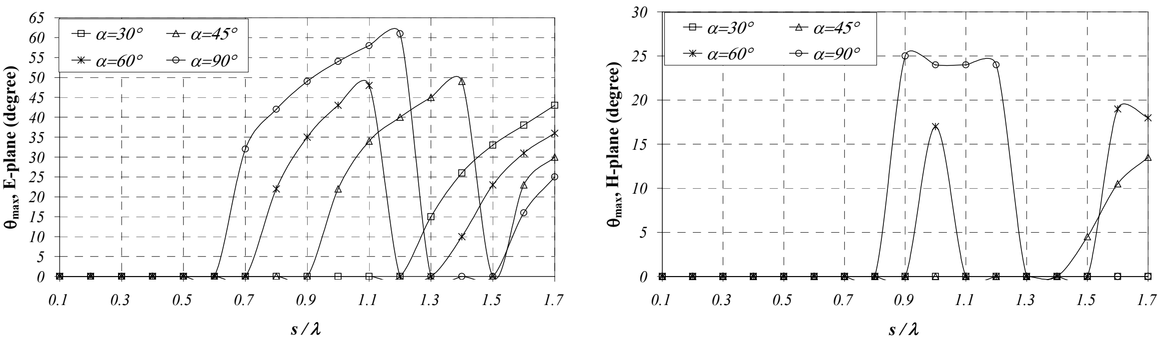
(a) E-plane (b) H-plane

Fig.2 Radiation pattern of a probe inside rectangular ring feed the dihedral corner reflector.

Figs.2(a) and 2(b) show the radiation pattern of a probe inside rectangular ring feed the corner reflector for the included angles of 30°, 45°, 60° and 90° at the spacing of 0.6λ in E-plane and H-plane, respectively. It is found that the unidirectional beam is obtained and becomes narrower as the included angles decrease.

3.2 Elevational and azimuthal beam peak

The unidirectional beam in boresight axis occurs when the elevational beam peak is 90° and the azimuthal beam peak is 0°. So, the elevational beam peak less than 90° or the azimuthal beam peak greater than 0° is not the unidirectional beam. Figs.3(a) and 3(b) show the elevational and azimuthal beam peak of a probe inside rectangular ring feed the dihedral corner reflector as the function of the spacing in E-plane and H-plane, respectively. It is noted that the unidirectional beam can be realized when the elevational beam peak in E-plane and azimuthal beam peak in H-plane directs toward x-axis. It is found that the unidirectional beam is achieved only some specific spacing. The unidirectional beam can be provided when the spacing is not greater than 1.2λ and 0.9λ for the included angles of 30° and 45°, respectively. The included angles of 60° will give the undirectional beam when the spacing is 0.1λ to 0.7λ and 1.2λ to 1.3λ, while the unidirectional beam is acquired when the spacing is 0.1λ to 0.6λ and 1.3λ to 1.5λ for the included angle of 90°. The result of this investigation is very important in the further antenna design.



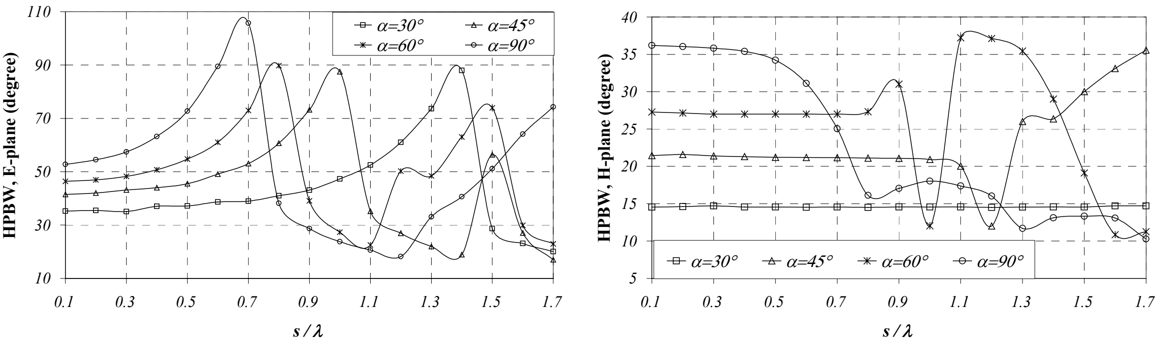
(a) Elevational beam peak (E-plane) (b) Azimuthal beam peak (H-plane)

Fig. 3 Beam peak of a probe inside rectangular ring feed the dihedral corner reflector

3.3 Beamwidth

A. Half power beamwidth

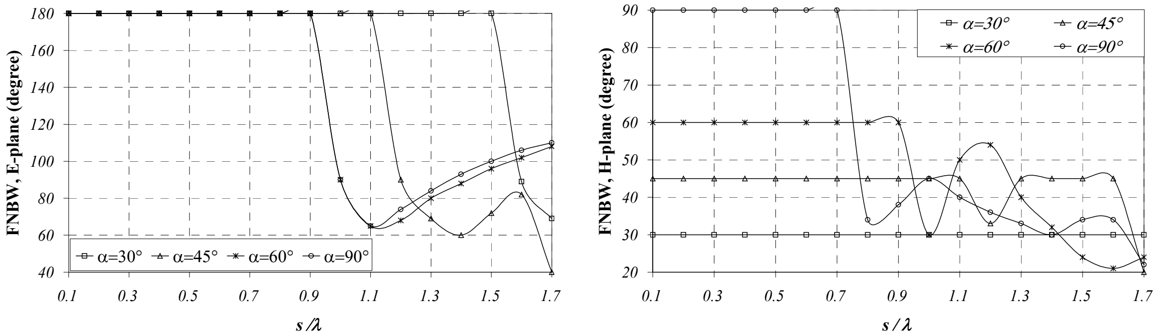
Half power beamwidth is an important parameter to evaluate the merit of the antenna [9]. It is desirable for the antenna to possess the narrow beamwidth. Figs.4(a) and 4(b) illustrate the half power beamwidth of the antenna against the spacing in E-plane and H-plane, respectively. It is evident that the half power beamwidth in E-plane pattern monotrary wider when the spacing is larger until 1.4λ, λ, 0.8λ and 0.7λ for the included angles of 30°, 45°, 60° and 90°, respectively. However the half power beamwidth in H-plane pattern will not change for the spacing less than 1.7λ, 1.1λ and 0.8λ for the included angles of 30°, 45° and 60°, respectively. The beam of included angle 90° will be narrower as the increment of spacing until 0.8λ. After that the beam of all cases will be swing. Moreover, the beam in E-plane pattern is almost wider than the H-plane pattern for almost cases.



(a) Half power beamwidth (E-plane) (b) Half power beamwidth (H-plane)

Fig.4 Half power beamwidth of a probe inside rectangular ring feed the dihedral corner reflector.

B. First null beamwidth



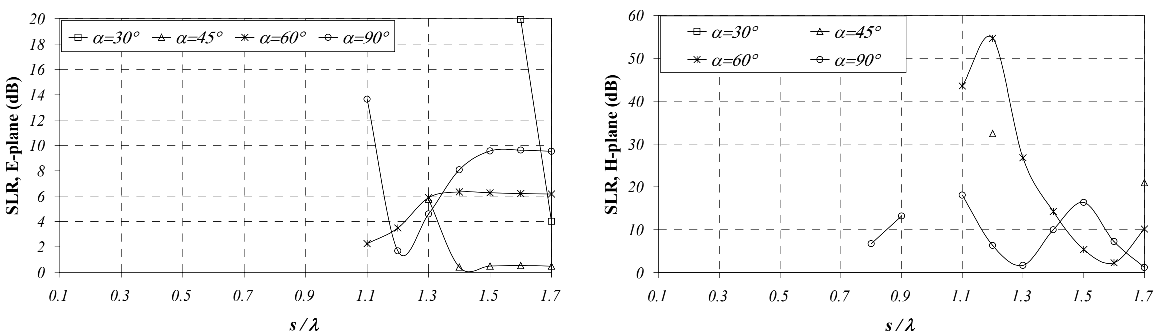
(a) First null beamwidth (E-plane) (b) First null beamwidth (H-plane)

Fig.5 First null beamwidth of a probe inside rectangular ring feed the dihedral corner reflector.

Figs.5(a) and 5(b) illustrate the first null beamwidth in E-plane and H-plane, respectively. The first null beamwidth in E-plane keep the constant value of 180° for larger spacing of the included angles of 30° and 45° less than 1.5λ and 1.1λ, respectively, for 0.9λ for the included angles of 60° and 90°. However, the same trend of variation of first null beamwidth in E-plane can be inspected viz., the antenna beam will not changed as the spacing increased until 1.7λ, 1.1λ, 0.9λ and 0.7λ for the included angles of 30°, 45°, 60° and 90°, respectively.

3.4 Side lobe ratio

Fig.6(a) and Fig.6(b) illustrate the side lobe ratio as a function of the element spacing. It is found that the side lobe ratio in E-plane pattern will be occurred since the spacing is 1.6λ and 1.3λ for the included angles of *30°* and *45°*, respectively, and 1.1λ for both included angles of *60°* and *90°*. There is no side lobe occurred for H-plane pattern of the included angle of *30°*. Moreover, the side lobe of the included angle of *60°* is occurred only at the spacing of 1.3λ and 1.7λ. The side lobe ratio in H-plane pattern is obtained when the spacing more than 0.7λ for the included angle of *60°*, and 1.1λ for the included angle of *90°*. Furthermore, the minimum side lobe ratio is obtained at the spacing of 1.4λ for the included angle of *45°* and the spacing of 1.7λ for the included angle of *90°* in E- and H-plane pattern, respectively.



(a) Side lobe ratio (E-plane) (b) Side lobe ratio (H-plane)

Fig.6. Side lobe ratio of a probe inside rectangular ring feed the dihedral corner reflector.

3.5 Directivity

Ultimately, the directivity of the antenna is shown in Fig.7. It is apparent that the maximum directivity for the included angles of 30° and 45° are 16.85 dBi and 15.39 dBi, respectively. The included angles of 60° and 90° yield 16.05 dBi and 15.7 dBi directivity at the spacing of 1.3λ and 1.5λ, respectively. Following the previous section, a unidirectional beam can be provided in the different spacing for each case viz., $0.1\lambda \le s \le 1.2\lambda$ for the included angle of 30°, $0.1\lambda \le s \le 0.7\lambda$ for the included angle of 45°, $0.1\lambda \le s \le 0.7\lambda$ and $1.2\lambda \le s \le 1.3\lambda$ for the included angle of 60° and $0.1\lambda \le s \le 0.6\lambda$ and $1.3\lambda \le s \le 1.5\lambda$ for the included angle of 90°. Moreover, the spacing between the probe inside rectangular ring (with the dimension of a=0.69λ, b=0.35λ and c=0.25λ) and the corner reflector for realizing a unidirectional beam must be considered. Thus, the spacing between the probe inside rectangular ring and the corner reflector needs larger spacing than 1.36λ, 0.91λ, 0.67λ and 0.42λ for the included angles of 30°, 45°, 60° and 90°, respectively. Accordingly, we can summarize that the maximum directivity is achieved when the included angle is 60° at the spacing of 1.25λ. However, the effect of the finite size of the corner reflector is not completed in this paper. It is now under investigation.

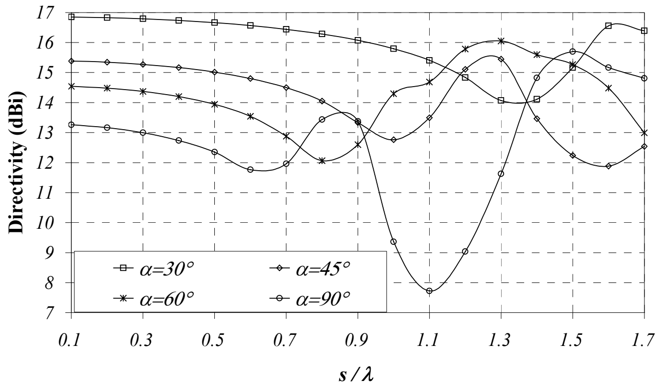


Fig.7. Directivity of a probe inside rectangular ring feed the dihedral corner reflector.

4. Conclusions

Radiation characteristics of a unidirectional beam antenna using a probe inside rectangular ring feed the dihedral corner reflector is analyzed in this paper. The radiation characteristics are comparatively studied among the included angles of 30°, 45°, 60° and 90°, respectively. It is found that the probe inside rectangular ring feed the dihedral corner reflector for the included angle of 60° provides higher directivity than the others. The optimum spacing between the antenna and the vertex of the dihedral corner reflector for the included angle of 60° that accomplish the maximum directivity for the antenna is *1.25λ*. The result of the analysis is very useful for the design of the high directivity unidirectional beam antenna.

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