Wide Beamwidth Quadrifilar Helix Antenna with Improved Axial Ratio

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Abstract - **This paper proposes a quadrifilar helix antenna (QHA) to provide wider elevation angle with low axial ratio. To improve the axial ratio (AR) over a broad angular region, inverted conical reflector and cylindrical reflector on inverted cone are introduced under QHA. The overall antenna including a feeding network and a radome is 110 mm in diameter and 142 mm in height and it has a gain of over -1 dBic and an AR of below 4 dB in forward hemisphere for S-band (2.0~2.3 GHz). The proposed two reflectors are effective in reducing cross-polarization but also increasing radiation angle with Low AR.**

Index Terms — **Quadrifilar Helix Antennas, reflector, hemispherical radiation pattern, Circular polarization.**

1. Introduction

Applications of Circular polarized (CP) antenna have been expanding in satellite communication, Global Navigation satellite system (GNSS), satellite broadcasting system, radio frequency identification (RFID), and so on. In many occasions, CP antennas are required to have lightweight, broad coverage and low cross polarization over the entire upper hemisphere. Quadrifilar Helix Antennas (QHAs) are widely used in many applications because of its properties of compact mechanical configuration and design flexibility for required coverage [2-4]. Some studies have been performed to increase the gain at low elevation angle and widen the beamwidth [5-10].

This paper proposes a QHA with wider elevation angle with low axial ratio for S-bans Satellite applications. To improve the axial ratio (AR) over a broad angular region, inverted conical reflector and cylindrical reflector on inverted cone are introduced under QHA. Performances of the QHA with two proposed reflectors are analyzed. Finally, performances of the antenna including a feeding Network and a radome are investigated.

2. Design of QHA and reflectors

The quadrifilar helix antenna consists of four helices equally spaced circumferentially on a cylinder which has 26.6 mm in diameter (R_A*2) and 53 mm in height(H_A), mounted on the proposed reflector as shown in Fig. 1. The number of turns is 0.37. All helices are shorted by a ring strip at the top of QHA and each helix fed with equal amplitude signals with relative phases of 0°,- 90°, -180°, and - 270°.

The proposed reflector reflects and diffracts backward radiated fields of QHA. Let us being by assuming that the source is placed at the top of the antenna (H_A of height) on the reflector. The incident angle of the field from the source determines the direction of reflection. Therefore, the reflection region is determined by changing the radius of the reflector. The incident field is also diffracted by the wedge of reflector. So the region of the diffracted field is dependent upon the angle of the wedge reflector.

Fig. 2(a) shows the AR characteristics with respect to elevation angle (theta) for various R_U, radius of reflector. In the analysis, the wedge of reflector is fixed at $\theta_W = 90°$ (i.e. R_U = R_L). As the radius of reflector is increased, the improved AR characteristic is observed at wider beamwidth by expanding the reflection region.
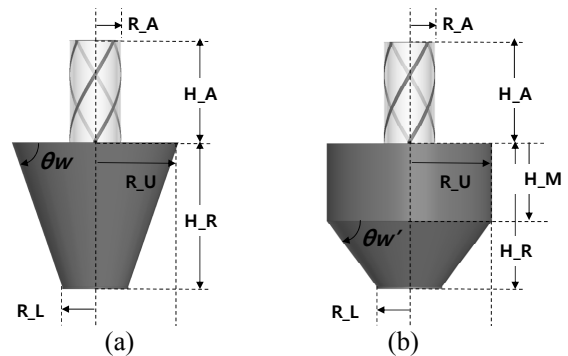

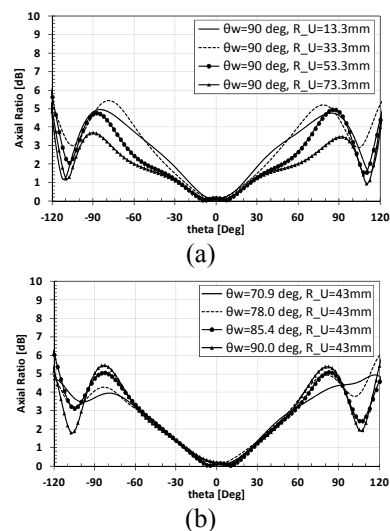Fig. 1. Geometry of QHA with two type reflectors. (a) inverted conical and (b) cylindrical on inverted cone.

(a)

(b)

Fig. 2. Simulated AR characteristics for design parameter values: (a)Variation in R_U, (b)Variation in θw in Fig.1 (a).
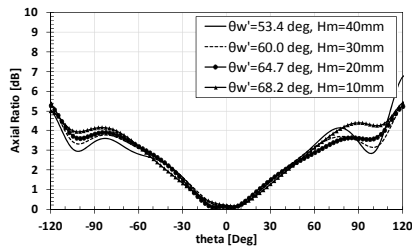
Fig. 3. Simulated AR characteristics for variation in H_M in Fig.1(b).

The AR characteristics with respect to elevation angle for various wedge angles (θ_W) are illustrated in Fig. 2 (b). When θW decreases, the AR becomes lower at 90° < theta < 70° and -70° < theta < -90°. Therefore, the inverted conical reflector has the advantage over the cylindrical reflector in improving an AR. Fig. 3 shows the AR characteristics with respect to elevation angle for various H_M in Fig.1 (b). When H_M increases (θ_W' is deceased), the AR is further improved.

3. Implementation of the proposed antenna module

The QHA is fed by a microstrip network integrated in the optimized reflector as shown in Fig. 4 (a). Fig. 4 (b) and (c) show the feed network. It consists of one hybrid coupler, two Wilkinson power dividers and delay lines in order to feed each helix with equal amplitude and 90° phase difference. The antenna is covered by a thin GFRP radome. The overall antenna including a radome is 110 mm in diameter and 142 mm in height.

Simulated radiation characteristics of the implemented antenna are illustrated in Fig. 5. The VSWR was lower than 1.5 over the whole S-band (2.0~2.3 GHz). As shown in Fig. 5(a) and (b), it has a RHCP gain of over -1 dBic and an AR of below 4 dB in forward hemisphere(-90° < theta < 90°) which is sufficient to cover the S-band.

4. Conclusion

In this paper, a quadrifilar helix antenna (QHA) for S-band satellite communications is proposed. To provide wider elevation angle with low axial ratio, inverted conical reflector and cylindrical reflector on inverted cone are introduced under QHA. The overall antenna including a feeding network and a radome is 110 mm in diameter and 142 mm in height and it has a gain of over -1 dBic and an AR of below 4 dB in forward hemisphere for S-band (2.0~2.3 GHz). The proposed two reflectors are effective in reducing cross-polarization but also increasing radiation angle with Low AR of QHA. Therefore, the proposed QHA can be applied in satellite communication systems, GNSS, RFID, and so on.
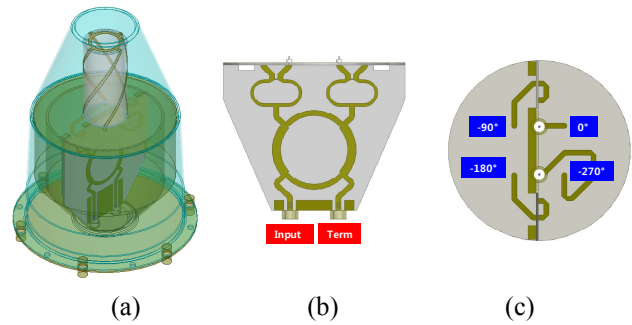
Acknowledgment

(a)   (b)   (c)

Fig. 4. Configurations of the realized antenna: (a) Perspective, (b) side and (c) bottom view of feed network.
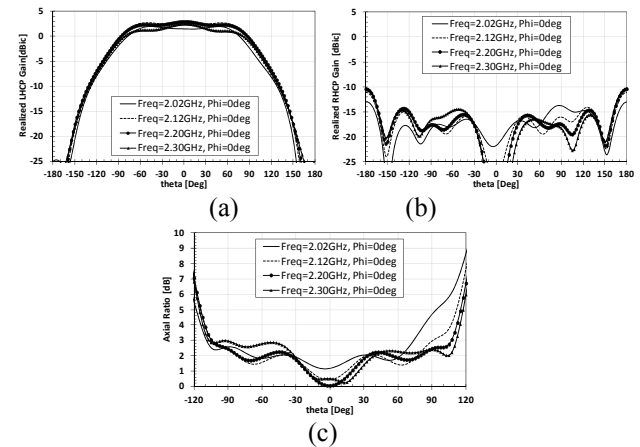

(a)   (b)

(c)

Fig. 5. Simulated radiation characteristics of the implemented antenna: (a) RHCP Gain, (b) LHCP Gain, and (c) Axial Ratio.

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