Design of a Ka-band Circularly Polarized Waveguide Antenna with a Cross Iris

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Abstract - In this paper, a Ka-band circularly polarized (CP) waveguide antenna with a cross iris is proposed. In order to achieve the CP characteristic of the antenna, a hexagonal shaped cavity is used. By using a cross iris, the axial ratio bandwidth is broadened. The 3-dB axial ratio bandwidth is 6480 MHz (31.97 – 38.45 GHz). The impedance matching is optimized by adjusting the proper sizes of a hexagonal cavity and a radiation slot. The 10-dB return loss bandwidth is 6840 MHz (31.74 – 38.58 GHz). The peak gains of the proposed antenna are 9.11 dBi at 33.5 GHz and 8.72 dBi at 37.6 GHz, respectively.

Index Terms — Waveguide antenna, Ka-band, circular polarization, axial ratio enhancement

1. Introduction

Recently, a millimeter-wave communication system has attracted a lot of attention because it can support higher data rate and large capacity. Therefore, mmwave frequency is widely used in various applications such as 5G mobile, satellite, military, and automotive communication. However, mmwave signals can be easily distorted by atmospheres like fog and dust [1]. In order to overcome this problem, waveguide antennas are considered to be one of the most proper antennas in mmwave application due to its high power handling, high gain, and low transmission loss capability. Since circular polarization (CP) characteristic is useful for the path loss compensation, some studies on mmwave CP antenna have been proposed [2,3]. However, there are only a few researches available on the waveguide CP antenna with wide axial ratio bandwidth.

In this paper, a Ka-band circularly polarized waveguide antenna with a cross iris is proposed. To achieve the circular polarization mode, a hexagonal shaped cavity is used [4]. The 3-dB axial ratio bandwidth of the proposed antenna is improved to 18.4% (31.97 - 38.45 GHz) by using a metallic cross iris. The 10-dB return loss bandwidth is 19.4% (31.74 - 38.58 GHz). The antenna has peak gains of 9.11 dBi at 33.5 GHz and 8.72 dBi at 37.6 GHz. Boresight gains are 8.3 dBi and 4.4 dBi, respectively.

2. Antenna Design and Results

Fig. 1 shows the geometry of the proposed antenna. The antenna is composed of a WR-28 waveguide, hexagonal cavity, metallic cross iris, and radiation slot. The WR-28 (3.56 x 7.11 mm²) waveguide is used as a fed waveguide to operate at Ka-band. The width of fed waveguide is chosen to be 10.1 mm to accommodate the hexagonal cavity. As shown in Fig. 1(b), the hexagonal cavity is designed to obtain the circular polarization with a size of 4.4 mm x 6.5 mm and a height of 2.5 mm. In order to enhance the axial ratio bandwidth, the 0.3 mm thick metallic cross iris is embedded at the bottom of the WR-28 waveguide. The distance between a center of an iris and back-shot is 6.6 mm. The iris is comprised of two different lengths. The radiation slot is located at the top of the antenna with an overall dimension of 4.4 mm x 6.5 mm x 0.5 mm. To investigate the effect of the cross iris, the simulated return loss and axial ratio results of the proposed antenna with and without cross iris are compared in Fig. 2. The antenna without cross iris has the same structure as the
proposed antenna except for a cross iris. As shown in Fig. 2(a), the impedance matching is significantly improved by using a cross iris. The 10-dB return loss bandwidth is 6.84 GHz ranging from 31.74 GHz to 38.58 GHz. In Fig. 2(b), one can observe that the CP mode generated by a hexagonal cavity, is further improved by adding a cross iris. The simulated 3-dB axial ratio bandwidth of the proposed antenna is 6.48 GHz (31.97 - 38.45 GHz).

Fig. 3 shows the simulated return loss characteristic of the antenna having different $h_w$ (width of the hexagonal cavity). As $h_w$ increases, the whole frequency band is shifted to the lower frequency side while the impedance matching is improved. It can be interpreted that the operating frequency is heavily affected by the size of a hexagonal cavity.

Fig. 4 shows the simulated radiation patterns of the proposed antenna at 33.5 GHz and 37.6 GHz in xz and yz plane. The antenna has peak gains of 9.11 dBi at 33.5 GHz and 8.72 dBi at 37.6 GHz. Boresight gains are 8.3 dBi and 4.4 dBi, respectively.

3. Conclusion

In this paper, a Ka-band circularly polarized waveguide antenna with a cross iris is proposed. WR-28 waveguide is used for Ka-band operation. By using a hexagonal shape cavity, the circular polarization property is realized. A wide axial ratio bandwidth is obtained by adding a cross iris. The proposed antenna could be a good candidate for the millimeter wave application.

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References