Bandwidth Enhancement of Circularly Polarized Waveguide Antenna Using L-shaped Probe

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Abstract

Circularly polarized broadband antenna using waveguide and an L-shaped feed probe is presented. The effect of the diameter of the L-shaped feed probe is investigated and four square poles are installed at the inside corner of the waveguide to enhance the bandwidth in S_{11} and AR.

Keywords : Waveguide antenna Circularly polarization Broadband characteristics L-shaped feed probe

1. Introduction

Recently, wireless communications such as satellite communication, wireless LAN and RADARs have expanded rapidly. At the same time, the communication speed and the volume of information have also been increased. For these networks, circularly polarized broadband antennas are helpful in reducing multipath fading. Also, broadband circular polarization can be used in pulse RADARs in order to avoid the clutter effect caused by reflected waves. So, circularly polarized broadband antennas have been studied and received much attention [1]-[6].

A waveguide antenna is presented in [3] to attain broadband circularly polarized characteristics and high gain. The antenna has a simple waveguide structure using an L-shaped feed probe. This antenna has an AR bandwidth of 27 %. The L-shaped probe is also used in [4]-[6] to generate circularly polarization easily.

In this paper, the thickness of the L-shaped probe is changed to improve the impedance and circular polarization characteristics. In addition, four square poles are inserted at the inside corner of the waveguide to broaden the circularly polarization bandwidth. The simulation results of this paper were obtained using Ansoft HFSS 10.1 which employs finite element method (FEM). The fabricated antenna shows good agreement with the simulation results.

2. Antenna Structure

Fig. 1 shows the proposed circularly polarized antenna with the L-shaped probe. The L-probe is placed in perpendicular to the direction of the propagating wave and at a distance of a quarter–wavelength from the closed backside wall. The center frequency is designed at 7.8 GHz. The waveguide has a square cross-section to degenerate TE_{10} and TE_{01} components of circular polarization.

Fig. 2 shows the enlarged picture of the feeding part. r_p is the diameter of the horizontal component of the L-shaped probe. As r_p increases from 0.8 mm to 2.0 mm, the current distribution on the horizontal probe lowers. This improves the amplitude ratio characteristics as showed in Fig. 3 and thereby the AR characteristics. The phase difference characteristics are not affected by variation in r_p. In addition, the impedance becomes more capacitive with the increase in r_p and broadband S_{11} characteristics could be obtained when $r_p = 2.0$ mm.

The feature of propagation mode changes when frequency of propagating wave changes in the waveguide. The higher-order degenerative modes such as TE_{11} and TM_{11} theoretically exist beyond 8.4 GHz in addition to the fundamental modes of TE_{10} and TE_{01}. The higher-order modes deteriorate the AR at higher frequencies. Therefore a novel structure to remove the higher-order modes is shown in Fig. 1. Four square poles (8 mm×8 mm×5 mm) are inserted at the inside corner of the waveguide.

3. Simulated and measured results

The proposed antenna with square poles inserted (called *antenna 3*) is compared with *antenna 1* (antenna before the improvement) and *antenna 2* (antenna without square poles inserted) and is shown in Fig. 4. The AR characteristics are improved from 27 % to 50 % from Ref. [3] to *antenna 3*. The S_{11} characteristics showed 29.8 % in *antenna 1*. This could be improved to 38.2 % in *antenna 2*. The *antenna 3* could further improve the S_{11} characteristics to 42.3 %. The antenna is fabricated and the measured result shows the -10 dB S_{11} bandwidth of 45.5 % (from 6.91 to 10.98 GHz) in Fig. 5 (a). In the AR characteristics as shown in Fig. 5 (b) 3 dB bandwidth of 49.4 % (from 6.44 to 10.67 GHz) is obtained in the +x direction. The gain characteristics in Fig.5(c) also show good agreement between simulation and measurement.

The simulated and measured radiation patterns at three frequencies (6.5, 8.0, and 10 GHz) are shown in Fig. 6 and Fig. 7. The azimuth angles in each pattern start from the +x direction for x-y plane and x-z plane. There is good agreement between the measured and simulated patterns. The radiation patterns at 10 GHz show high cross polarization. This is because of the influence of the higher-order modes.

4. Conclusion

The effect of the change of the diameter of the L-shaped probe r_p and the addition of square poles has been presented to improve the circularly polarization characteristics. The antenna has a simple waveguide structure with an L-shaped feed probe. The proposed antenna achieved an AR bandwidth of 49.4 % and an S_{11} bandwidth of 45.5 % in measurement. This antenna has a maximum gain of 9 dBic and is a suitable candidate for pulsed RADARs. The improvement of the further gain is anticipated by attaching a circular horn.

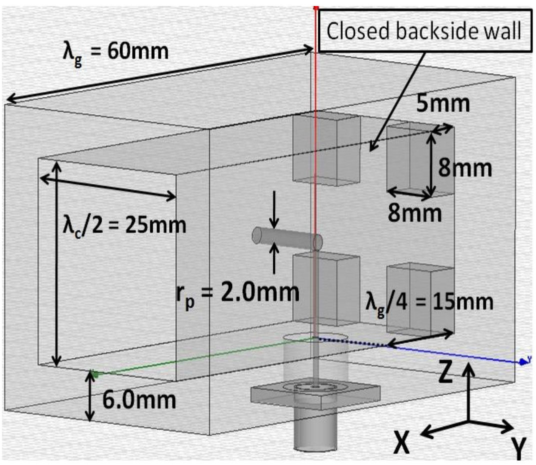


Figure 1: Proposed structure

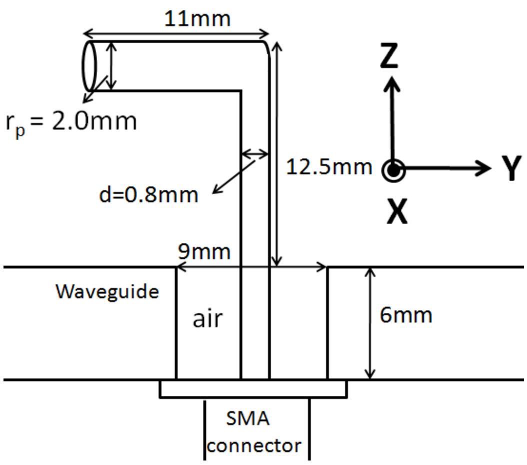


Figure 2: Feeding part

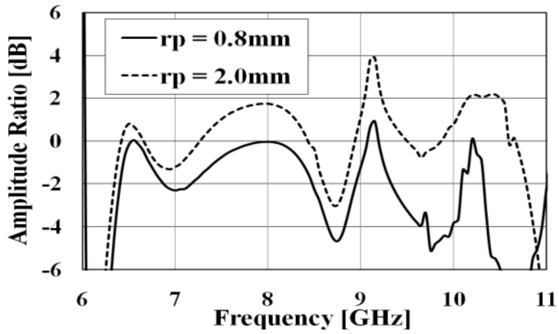
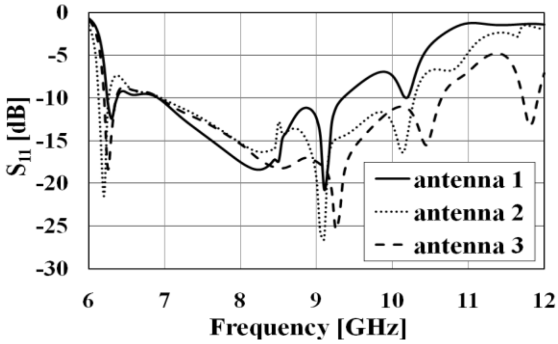
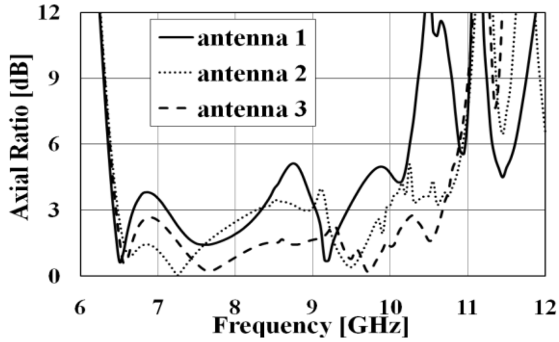


Figure 3: Amplitude ratio characteristics

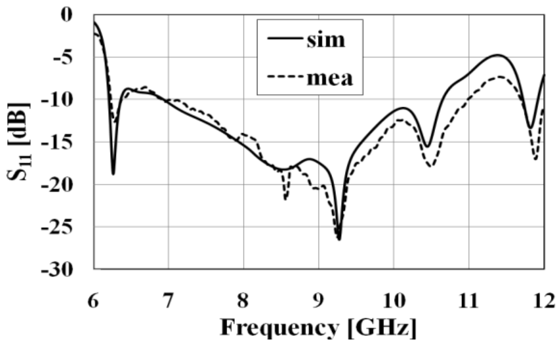


(a) S_{11} characteristics

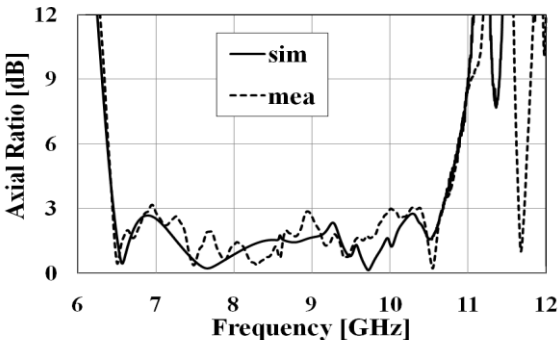


(b) Axial ratio characteristics

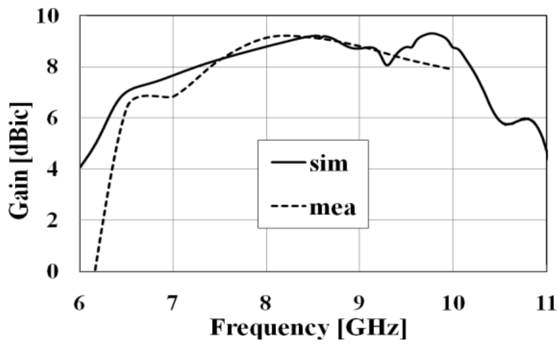
Figure 4: Comparison of antenna



(a) S_{11} characteristics

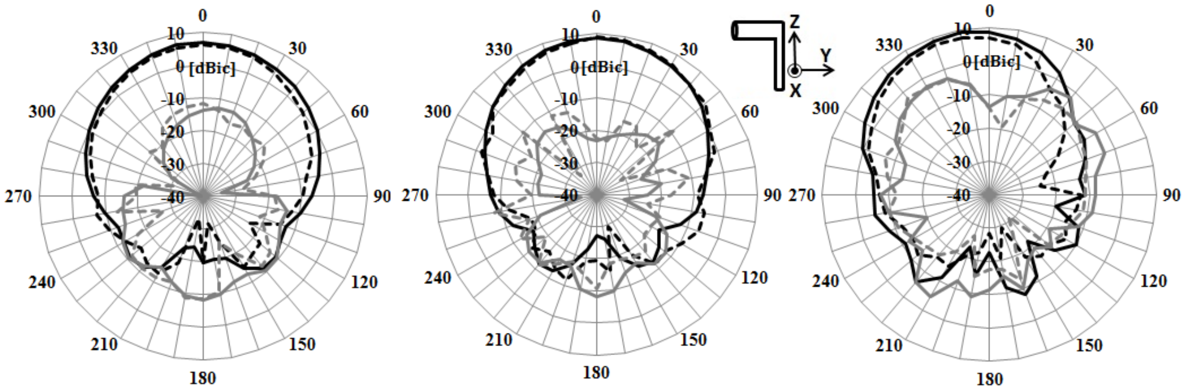


(b) Axial ratio characteristics



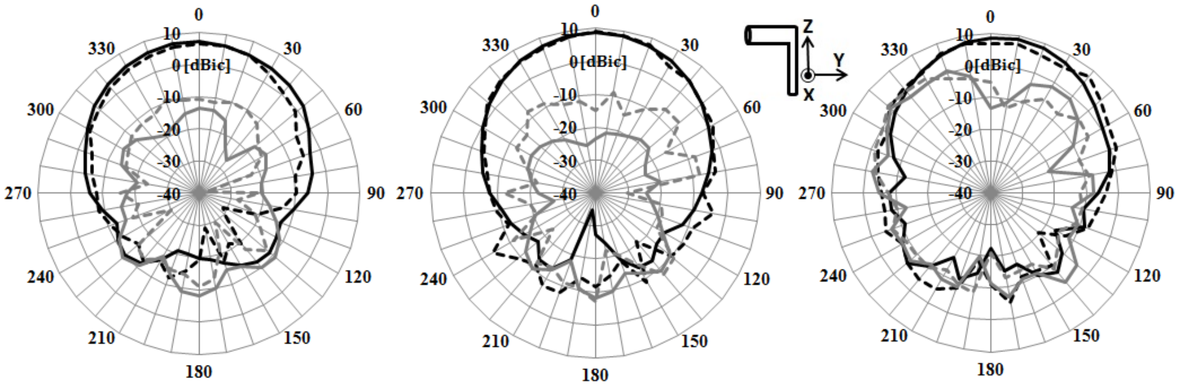
(c) Gain characteristics

Figure 5: Simulated and measured results



(a) 6.5GHz (b) 8.0GHz (c) 10GHz

Figure 6: Simulated and measured radiation pattern in x-y plane



(a) 6.5GHz (b) 8.0GHz (c) 10GHz

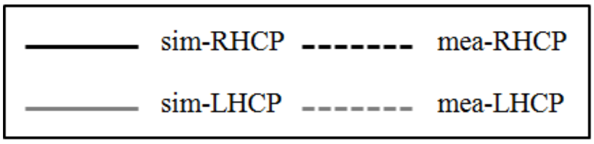


Figure 7: Simulated and measured radiation pattern in x-z plane

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