A Newdual circularly polarized antenna at Ka band

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Abstract

A new dual circularly polarized antenna at Ka band is described in the paper. The proposed antenna consists of a stepped septum polarizer and a current-choking flange slot. The dimensions of the stepped septum polarizer and the flange slot are optimized by the HFSS software. Comparing to the traditional antennas with septum circular polarizers, the simulation results indicate that without increasing the overall size the proposed structure which implements identical beam-widths for two orthogonal planes, high isolation between ports and smoothing axial-ratio fluctuations across a 3 GHz bandwidth.

2. Introduction

In recent years, C band and Ku band are widely applied in satellite communication; however, the resource of C band and Ku band is limited. To meet the requirement of commercial satellite communication, there has been an increasing research on Ka band satellite communication. The radio data link between vehicle and satellite should satisfy the requirement of long distance and long time. As one of the important devices, the antenna transmits data from vehicle to satellite and receives information from satellite simultaneously. The wideband circularly polarized and wide-beam angle capability antennas [1-2] can promote the performance of the radio system, especially on a lower elevation angle. The dual circularly polarized antennas [3-4] transmit and receive signal with different circularly polarized (right hand circularly polarized and left hand circularly polarized) signal simultaneously. Dual circularly polarized antennas are generally utilized to avoid fading loss, realize frequency reuse and enlarge system capability.

Stepped septum polarizers constitute a simple and compact device for converting linear polarization into circular polarization in the feed waveguide [5-7]. Stepped septum polarizers are widely applied in antenna feed system because of its compact structure, which provides improved isolation and broader bandwidth. Compared to the sloped septum polarizer, the stepped septum polarizer achieves higher isolation and broadband. However, the square waveguide with the stepped septum circular polarizer failed to implements identical beam-widths for two orthogonal planes, and the axis ratio of the main beam fluctuates obviously. However, the overall size of horn increasing and need design center frequency. In this paper, a current-choking flange slot is utilized to improve the performance of antenna t without increasing height.

3. Stepped Septum Polarizer Design

Stepped septum polarizers, built on a square waveguide with stepped ridged waveguide junctions, have found many applications in antenna systems and polarization measurement equipment. Such a configuration is highly acceptable for the antenna applications because it does not require any matching tools at a flange joint with conical smooth or corrugated horns. Design the stepped septum polarizers according to the desired specification of the return loss(RL), isolation (IS) between input

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waveguides, axial ratio (AR) of the resulting field generated by two outgoing orthogonal dominant modes, and suppression level (SL) of higher parasitic modes in the output port if the latter is oversized.

By carefully selecting the dimensions of the septum and exciting one of the rectangular waveguide ports withits dominant TE01 mode, orthogonal TE10 mode and TE01 mode can be generated when the wave leaves the septum. Since the septum region is equivalent to a ridged waveguide, the TE10 mode can propagate from rectangular waveguide section to septum-loaded section unaffected; whereas the propagation constant of the TE01 mode related to the step height and width of septum. By adjusting the step height and width of septum, the desired circular polarized electromagnetic wave can achieve.

The fundamental principal of the mechanism of the steppedseptum circular polarizer can be understood using S matrix analysis. In order to better understand the S matrix analysis of the septum and its mechanism of generating circularly polarized field, HFSS, a full-wave simulator is employed to analyze the septum. The stepped septum polarizers constitute a square waveguide and metallic septum, to simplify analysis, the stepped septum polarizers are regarded as four-port network as shown in Fig.1.

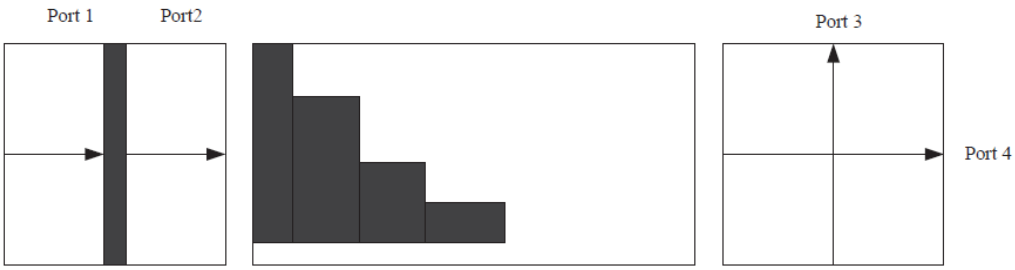


Fig.1Four-ports networkprototype of the stepped septum polarizers

4. Current-chocking Flange Slot Design

In this paper, a current-chocking flange slot is mounted around the antenna radiation end to improve the axial ratio and radiation pattern of the antenna. The prototype of the current-chocking flange slot is shown in Fig.2. Compared to traditional flange, the current-chocking flange slot is constituted of one or several ring slot with vertical wall from center waveguide edge. The slot width W is defined by the gap between two successive blocks. The current-chocking flange slot has one or more $\lambda/4$ deep slots, the thickness of blocks T is less than 0.05λ. The slot width W should be far greater than the thickness of blocks T. According to the gain requirement of the antenna, we can properly adjust the number of current-chocking slot.

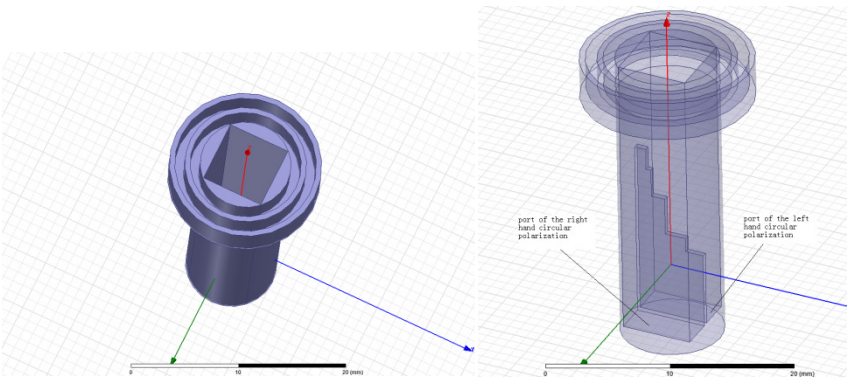


Fig.2 The prototype of the proposed antenna

5. Simulation and Experiment Results

A Ka band dual circularly polarized antenna was designed, simulated and optimized based on the designed procedure described in the previous sections. The configuration of the proposed antenna is shown in Fig. 2 and Fig. 3 shows the simulated VSWR of the proposed antenna. It can be seen from the figure that the value of voltage standing wave ratio (VSWR) at the center frequency is 1.02 and the maximum value of VSWR is less than 1.15, which satisfies the specification of commercial satellite communication. Fig. 5 and Fig. 6 shows the calculated axial ratio and radiation pattern, where the solid and dotted curves correspond to the dual circularly polarized antenna with current-chocking flange slot and without current-chocking flange slot, respectively. The performance of axial ratio and radiation pattern with current-chocking flange slot was significantly improved compared with that without current-chocking flange slot. The simulated radiation pattern for two orthogonal planes of the proposed antenna is shown in Fig. 5. This showed excellent symmetry. Moreover, good agreement can be observed between the two orthogonal planes. Fig. 5 shows that the front-to-back ratio with current-chocking flange slot is higher than the front-to-back ratio without current-chocking flange slot. Fig. 6 depicts the axial ratio for the -10 dB beamwidth(approx ±45°) for various axial planes within a range of 180 degrees, showing excellent circularity. This antenna performance satisfies the specification of commercial satellite communication. The simulated isolation between ports across a 3 GHz bandwidth is shown in Fig. 4. A high level of isolation was desirable, since otherwise an increase excessive energy coupling into the other port when a transmitter is used would be observed.

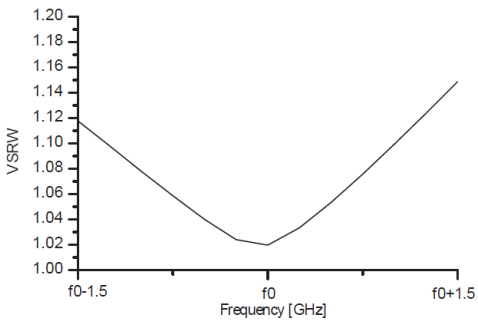


Figure 3. The simulated VSWR when Port1 is excited for LHCP polarization

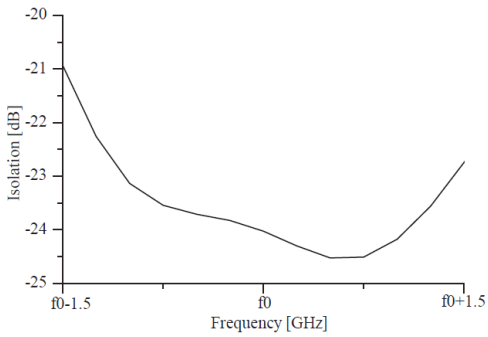
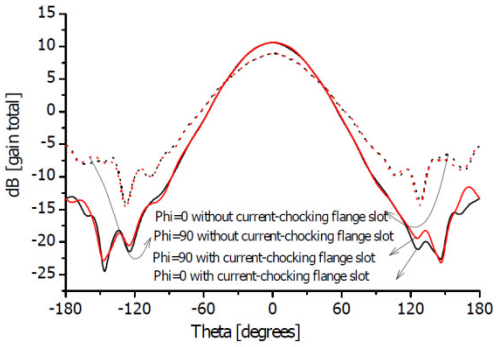
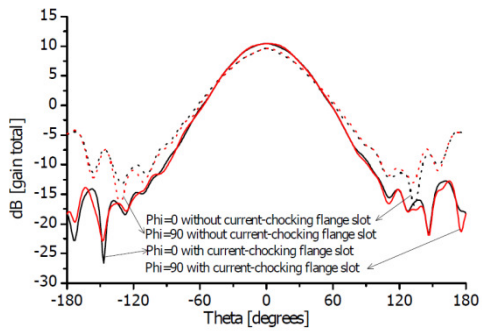


Figure 4. The simulated isolation between input ports across a 3GHz bandwidth

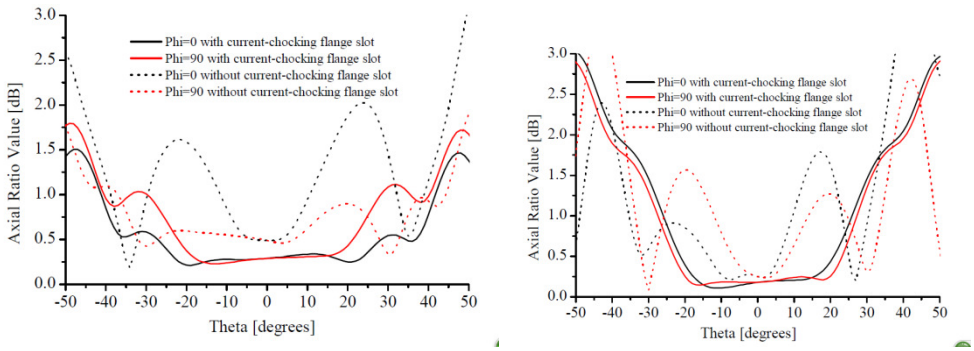


f-1.5GHz



f+1.5GHz

Figure5. The simulated radiation patterns in principal planes for LHCP polarization



f-1.5GHz f+1.5GHz

Figure 6. The simulated axial ratio in principal planes for LHCP polarization

6. Conclusion

A high-performance, dual circularly polarized antenna for Ka band commercial satellite communication was designed, and simulated. A five-step septum polarizer in a circular waveguide was used to achieve right hand circularly polarized and left hand circularly polarized simultaneously. Furthermore, a current-chocking flange slot is utilized to improve the performance. The proposed antenna proved to realize excellent impedance characteristic, low axis ratio and high level isolation across a 3GHz bandwidth. The proposed antenna can also serve as a well performed antenna feed for its compact structure.

7. Reference

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