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Research Article

Çapraz Şekilli Yönlendiricilere Sahip Dairesel Kutuplamalı Mikroşerit Yama Anten Tasarımı

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Öz

Bu makalede, çapraz şekilli iki yönlendiriciye sahip dairesel kutuplanmış bir mikroşerit yama anten sunulmaktadır. Yama anten ilk olarak geleneksel doğrusal kutuplanmış anten şeklinde tasarlanmıştır. Daha sonra antene dairesel bir kutuplanma özelliği kazandırmak için yamanın karşılıklı iki köşesi kırpılmıştır. Son tasarım aşamasında mikroşerit antenin yama yüzeyinin önüne kazancını artırmak için iki adet çapraz şekilli yönlendirici eklenmiştir. Antenin ayarlanabilir tüm geometrik özellikleri, her tasarım aşaması için parametre tarama yöntemiyle optimize edilmiştir. Yönlendiricilerin yardımıyla anten kazancı 3.99 dBi'dan 4.402 dBi'ya çıkarılmıştır. Önerilen antenin kazanç iyileştirmesinden sonra S_{11} ve eksenel oran (AR) özellikleri istenen aralıkta kalmaya devam etmiştir. Antenin rezonans frekansı 1700 MHz'den 1705 MHz'e hafifçe kayarken, AR başarılı bir şekilde 3dB seviyesinin altında kalmıştır.

Anahtar Kelimeler: Mikroşerit Yama Anten, Dairesel Kutuplanma, Yönlendiriciler, Eksenel Oran.

Design of A Circularly Polarized Microstrip Patch Antenna with Cross-Shaped Directors

Abstract

In this paper, a circularly polarized microstrip patch antenna with two cross-shaped directors is proposed. The patch antenna is first designed in the form of a traditional linear polarized antenna. Then, two opposed corners of the patch are truncated to give a circular polarization property to the antenna. In the last design phase, two cross-shaped directors are added in front of the patch surface of the microstrip antenna to increase its gain. All adjustable geometrical properties of the antenna are optimized by parameter sweep method for each design phase. The antenna gain is increased from 3.99 dBi to 4.402 dBi with the help of the directors. After the gain improvement of the proposed antenna, its S_{11} and axial ratio (AR) characteristics are still in the desired range. The resonance frequency of the antenna is slightly shifted from 1700 MHz to 1705 MHz whereas AR remains below 3dB level successfully.

Keywords: Microstrip Patch Antenna, Circular Polarization, Directors, Axial Ratio.

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1. Introduction

The polarization of an antenna can be linear, circular or elliptical, depending on the orientation of the vector defining the electric field at a point in space as a function of time [1]. Antenna polarization is a very important parameter as it will determine the application areas of the antenna [2]. When the electric and magnetic field vectors of an electromagnetic wave radiated from an antenna move in a circle as a function of time, this electromagnetic wave should have a circular polarization [3]. Antennas with circular polarization have some advantages over antennas having linear polarization. Examples of these advantages can be given as their resistance to various interferences, ability to reduce the effect of Faraday rotation, which is frequently encountered in linear polarized antennas and causes a loss of 3 dB or more due to the ionosphere, and no strict orientation between transmitting and receiving antennas is required [4]. Due to all these advantages, antennas with circular polarization are preferred in many applications such as wireless communication, satellite communication, radio frequency identification (RFID) applications and so on.

Microstrip antennas are preferred for many applications since they are able to meet several engineering requirements [5]. First of all, they mostly have a simple structure and can be fabricated easily [6]. They can be mounted on the curved surfaces as well as the planar ones [7]. Low profile and easy integration possibility with circuit elements are other advantages of microstrip antennas [8]. The conversion of a linearly polarized microstrip antenna design into a circularly polarized antenna is not a difficult task [9]. Two or more microstrip feeds might be used to bring about a circular polarization for a microstrip antenna. Besides, a single-feed technique can also be used with some simple asymmetric modifications on patch such as chamfer, slot and stubs [10]. However, the classical circularly polarized antennas have limited gain values compared to their helix and horn antenna alternatives.

In this study, a circularly polarized microstrip patch antenna design with two cross-shaped directors is proposed. First, a circularly polarized microstrip patch antenna with a coaxial feeding is predesigned to operate at a frequency of 1700 MHz. Then, 2 cross-shaped copper directors were added to the existing design in order to improve the gain parameter of the antenna. In order to see the quality level of the final antenna, the S_{11}, axial ratio (AR) and radiation pattern of the antenna are examined.

2. Antenna Design

In this study, the antenna is first designed as a single microstrip antenna with circular polarization. All simulations and design processes in this study are performed by the help of Comsol Multiphysics software. The substrate material is FR4 with 4.15 dielectric constant and 1.6 mm thickness. The antenna is energized with a single coaxial feeding as a lumped port as shown in Fig. 1. The length (L_{sub}) and width (W_{sub}) of whole substrate are both 80 mm. The geometrical optimizations are performed on the microstrip patch so that the resonance frequency can fit at 1700 MHz. The length and width of the copper patch are calculated as L_p= 38.3 mm and W_{sub} = 38.3 mm, respectively. The distance of the feed point to the nearest edge is obtained by the parameter sweep optimizations of Comsol as f_p=8.75 mm. The second aim is to gain a circular polarization during this optimization. In order to achieve this ability, two opposite corners of the patch are truncated. The chamfer length of these corners is ch_L=5.66 mm. In order to see the circular polarization performance of the patch antenna, the AR plot in dB is given in Fig. 3. As shown in the figure, the AR value of the antenna in the direction of the maximum radiation is below 3 dB.

After the design of the plain microstrip patch antenna having a circular polarization, it is aimed to improve the gain parameter of the antenna while its resonance frequency and polarization characteristics are preserved. For this aim, two cross-shaped parasitic directors are added in front of the patch. The final antenna design with directors is given in Fig. 4. The distance and the dimensions of the directors are determined by the parameter sweep method. The diameter of each cross-shaped director elements is equal, and it is $R_d = 2.7$ mm. Director lengths are the same for both directors and they are $L_d = 30$ mm. The distance of the first director to the antenna is $d_1 = 27.85$ mm while the distance of the second director to the antenna is $d_2 = 57.85$ mm. The geometrical model of the antenna given in Fig. 4 is the same as the patch antenna given in Fig.1, except the feed point. After adding the directors, the position of the feed point is adjusted again to find an optimal point for a stable resonance frequency. Eventually, f_p parameter is found as 9.95 mm for the new geometry.

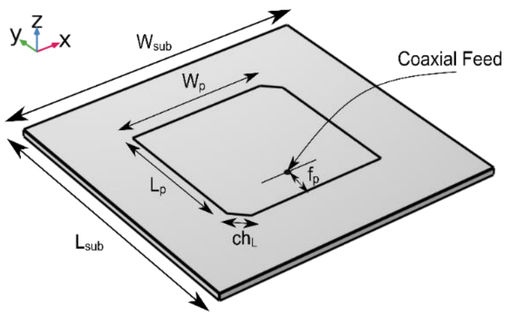

Figure. 1 Geometry of circularly polarized microstrip patch antenna

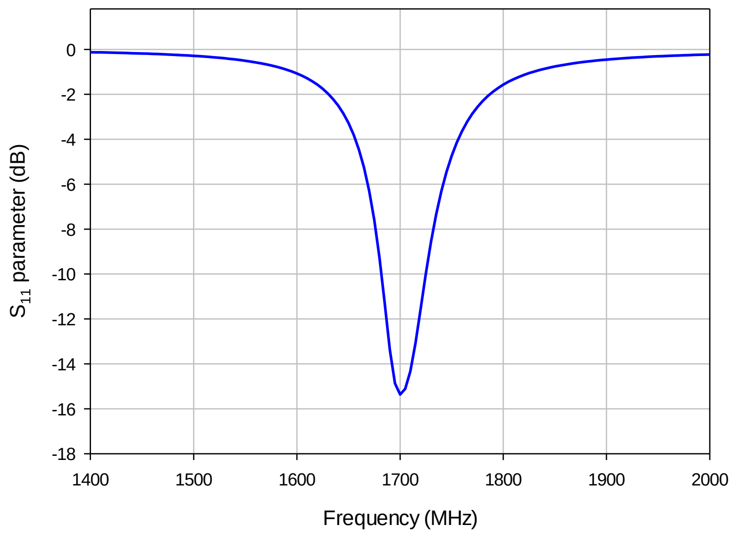

Figure. 2 The S_{11} plot of the circularly polarized microstrip patch antenna

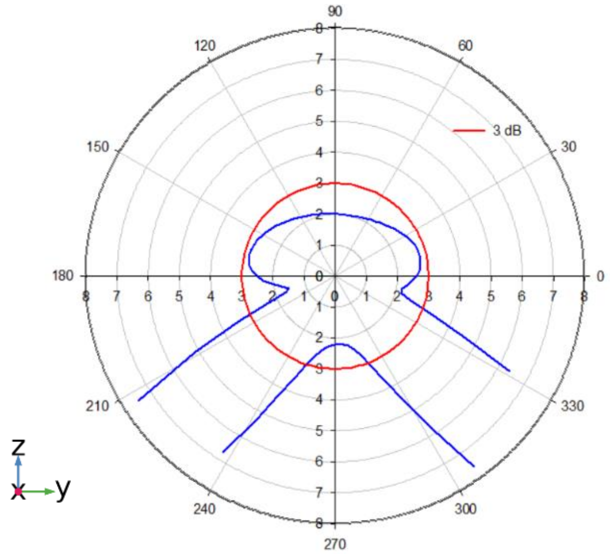

Figure. 3 The AR in dB plot of the circularly polarized microstrip patch antenna at 1700 MHz frequency

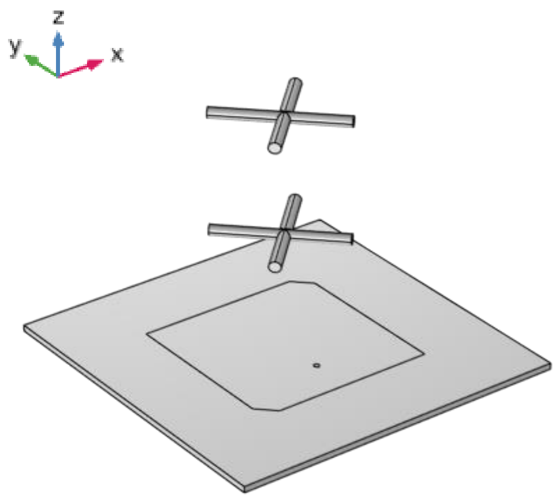

Figure. 4 Circularly polarized microstrip antenna with two cross-shaped parasitic directors

3. Simulation Results

In order to see the effect of the cross-shaped parasitic radiators, the S_{11}, AR, radiation pattern, and gain values of the final design of the proposed antenna are examined in this section. The S_{11} and AR plots of the preliminary design of the antenna are previously given in the design section. The S_{11} plot of the microstrip patch antenna with two cross-shaped directors is given in Fig. 5. From the figure, it is seen that resonance frequency of the antenna with two directors is shifted from 1700 MHz to 1705 MHz. It can clearly be considered as a slight difference. Similarly, Fig. 6 shows the AR graph of the final design of the antenna. The plot in the figure reveals that the AR value in the maximum gain direction is still lower than 3 dB. This means that the designed antenna has a good circular polarization characteristic.

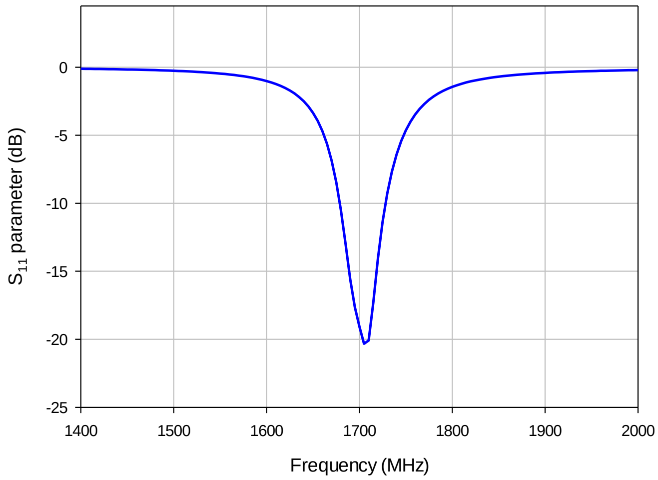

Figure. 5 The S_{11} plot of the circularly polarized microstrip patch antenna with two cross-shaped copper directors

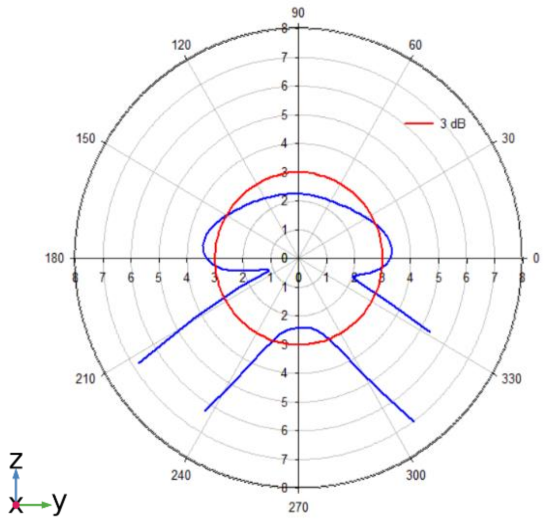

Figure. 6 The AR in dB plot of the circularly polarized microstrip patch antenna with cross-shaped directors at 1700 MHz frequency

The radiation patterns which are shown in 2D and 3D for the circularly polarized microstrip patch without the directors are given in Fig.7. The radiation patterns are constructed via Comsol software at 1700 MHz. The gain of the antenna without directors is 3.99 dBi at that phase. After adding cross-shaped directors to improve the directive properties of the antenna, the radiation pattern of its final design became as in Fig. 8. This last figure also owns the 2D and 3D radiation patterns for the final design of the circularly polarized microstrip patch antenna with two cross-shaped directors. At the center frequency of 1705 MHz, the gain of the antenna design is 4.402 dBi. The gain at the target frequency 1700 MHz is 4.386 dBi.

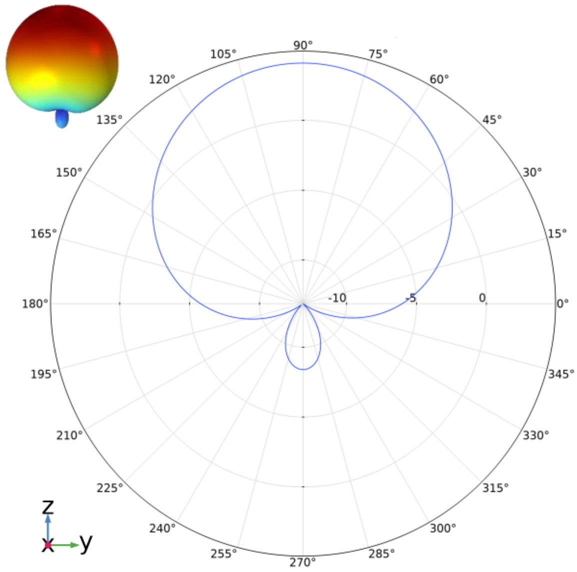

Figure. 7 2D and 3D plot of the circularly polarized microstrip patch antenna without cross-shaped directors

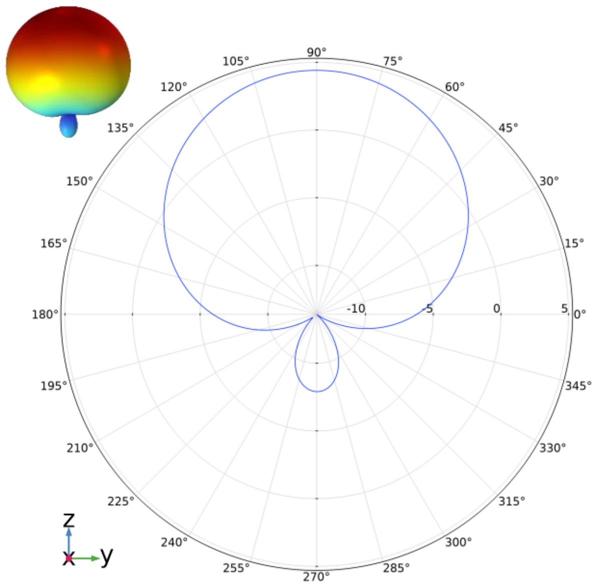

Figure. 8 2D and 3D plot of the circularly polarized microstrip patch antenna with cross-shaped directors

4. Conclusion

A circularly polarized microstrip patch antenna with two cross-shaped directors is presented. This directional antenna scheme is designed in two phases. In the first phase, a traditional microstrip patch antenna with coaxial feeding is designed. In order to give the antenna a circular polarization feature, its two opposed corners are truncated. The geometrical parameters of the patch antenna including the chamfer length are adjusted so that it can have a resonance frequency at 1700 MHz and an AR value below 3dB. In the second phase, two cross-shaped directors are added in the direction of the main beam of the radiation pattern in order to increase the gain of the antenna. The results show that the gain of the microstrip patch antenna is successfully increased while its reflection coefficient and AR parameters remain in the desired range.

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