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Circularly polarized cup shaped patch antenna for Ku band application

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Abstract

A simple and compact antenna with dual band along with dual circular polarization is designed. The proposed antenna resembles a cup like shape which is actually a semicircle attached to the microstrip feed line in the patch part. From the dual notch frequency band, the first notch is from 12.2 – 13.5 GHz, second notch is from 14.8 – 16.4 GHz.Both the first and second notch bandwidth falls under the Ku band which ranges from 12 – 18 GHz. The proposed antenna also satisfies the circular polarization whose axial ratio bandwidth comes under the range of impedance bandwidth with a frequency range of 12.3 – 13.2 GHz and 15.3 – 16.3 GHz which satisfies the frequency range of Ku band (12-18 GHz). The simulation process is carried out by using the software Ansoft commercial high frequency structure simulator (HFSS ver. 21).

Subject Classification: *78-04, 78-05, 78A50.*

Keywords: *Circular polarization, Axial ratio, Bandwidth, Radio frequency, Microstrip patch, Antenna, Ku band, Radiation, Dual band.*

1. Introduction

An antenna is a wireless device that can transmit the radio signals to the free space in the form of electromagnetic waves and can receive back the signal from free space through the transmission lines in the form of guided waves [1]. In the current situation, wireless communication system is required with antennas having compact size, multiband in nature and can achieve a wide band too. For such condition, microstrip patch antenna has become a hot research topic in the broad area of

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communication [2]. The prerequisite for multiband frequency for each help increases due to steady progression of remote communications. The improvement of correspondence innovation has fundamental test as how to meet superior execution, minimal expense and small size. In the present circumstance there is a quick improvement in remote microwave gadgets which utilizes away at RF frequencies. Microstrip patch antenna is one of the major portions of the microwave gadgets [3]. Microstrip antenna possesses several advantages like conformability, light weight, fabrication process is easy, compatible with other devices and cost is also cheap [4]. Having all those advantages, microstrip antenna had attracted many researchers to carry their research on this area. Due to its low profile and light weight characteristics, it can be shaped into any type of structure. In real time applications, the patch antenna is mostly used in giga hertz frequency range on which the patches are considered to be very small having shorter wavelength. Mostly for the creation to be simple, their applications include devices which are remotely portable[5]. Micro-strip patch antenna consists of 3 parts; first one is "Patch" which is made up of metal substances like gold or copper. Second one is "Ground plane" which is larger in size in comparison to the patch and third one is "Substrate" which is sandwiched in between patch and ground plane [6]. Today, the rising interest for frequencies has prompted the presence of a few recurrence groups. Among them, there is the Ku band, which is the most utilized band of any remaining frequency bands for satellite and TV communication [7]. Circular polarized antennas are highly preferred over the linearly polarized antenna because the transmitting and receiving antenna do not require the line of sight. Generally using the printed slot antenna and microstrip patch antenna, circular polarization is achieved [8]. Interesting works are found on building up an antenna using different printed structures and monopole antennas in the recent literatures [7, 9-12]. In case of monopole antenna, it's quite complex for achieving circular polarization using ground plane of symmetric structure but however it can be achieved using asymmetric ground plane [13]. In this paper a cup shaped circularly polarized antenna is designed which operates in the Ku band and the structure is referred from the paper [14] in which the design was satisfying the UWB range where as in this paper it is being operated in Ku band along with dual circularly polarized. The antenna parameters, including length, width, resonant frequency which are listed in the antenna design section have been effectively calculated using the generalized antenna equations [15].

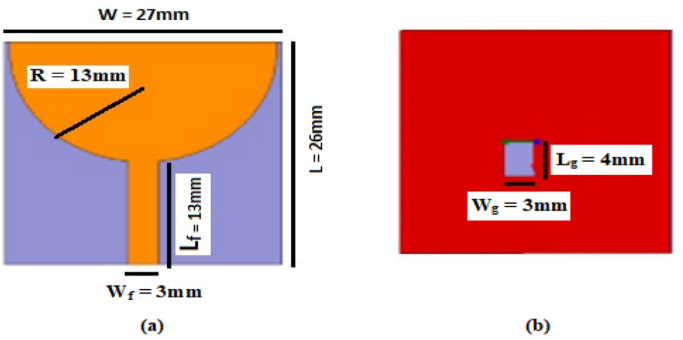


Figure 1

Geometrical structure of proposed antenna (a) Front view (b) Back view

2. Antenna Design

The geometrical structure of the designed antenna is depicted in the Figure 1. As shown in the below figure the antenna is fed by a microstrip feed line of 50 Ω which has been designed on a FR4 substrate which bear the relative permittivity = 4.4, loss tangent = 0.02 and thickness of 1.6mm. The overall dimension of the structure covers an area of 26 x 27 $mm^2$and a height of 1.6 mm which is compact in size. The structure looks like a cup which is actually a semicircle of radius 13mm. The feedline of size 13mm x 3 mm is connected to the semicircle which together forms the patch. The optimized parametric values of the designed antenna are presented in Table1.

The evolution process of the proposed antenna towards the realization of CP is shown in Figure 2 step by step. Ant 1 is the basic structure in which the ground plane of size 26mm x 27mm is drawn on which a

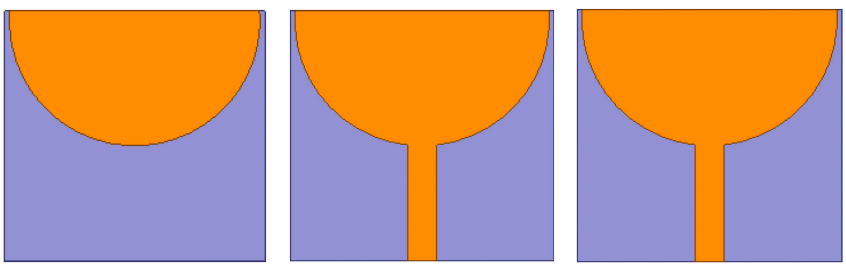


Figure 2

Evolution steps of the designed antenna

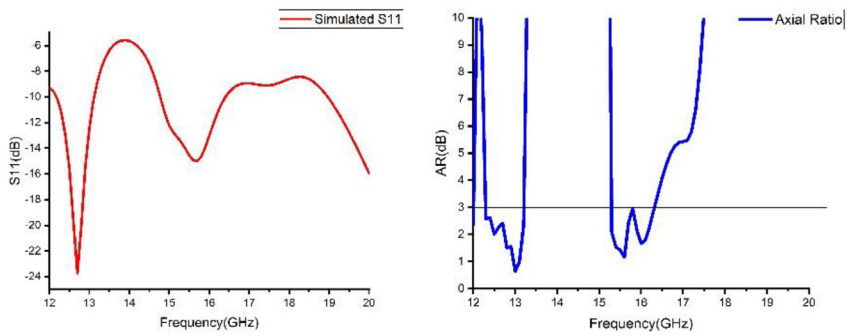
Table 1
Parametric values of the proposed antenna

Parameters	L	W	L_f	W_f	R	L_g	W_g
Dimension (mm)	26	27	13	3	13	4	3

substrate of same dimension along with a thickness of 1.6mm is placed and above the substrate a semi-circular patch of radius 13mm is drawn. In Ant 2 a microstrip feedline of 13mm x 3mm is inserted and is united with the semi-circular patch which finally looks like a cup and it is considered as the total patch of the structure. Ant 3 is the proposed antenna in which an additional rectangular patch having dimensions 4mm x 3mm has been cut in the ground plane in order to realize the circular polarization mechanism. The results of the designed antenna are shown in the below section.

3. Results and Discussions

The antenna was simulated with the help of Ansoft commercial high frequency structure simulator (HFSS ver. 21) software. To clearly understand the antenna design, the evolution process is shown above in Figure 2. To clarify the performances of the proposed antenna, the S11 plot and axial ratio plot are shown in Figure 3(a) and Figure 3(b) respectively. From Figure 3(a) we can say that as it is a dual notched frequency band filter so its first notch falls in the range of 12.2 – 13.5 GHz, second falls in



(a) (b)

Figure 3

(a) S11 plot (b) AR plot

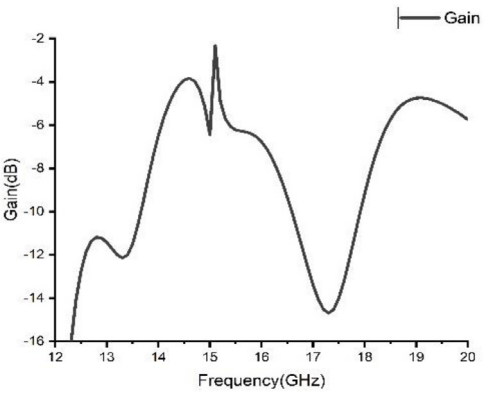


Figure 4
Gain plot

the range of 14.8 – 16.4 GHz which clearly indicates that it comes under the Ku band frequency radiation. Figure 3(b) is the plot of Frequency versus Axial ratio in which it clearly indicates that my axial ratio bandwidth is in the frequency range of 12.3 – 13.2 GHz and the second bandwidth is from 15.3 – 16.3 GHz which lies in between the impedance bandwidth of 12.2 – 13.5 GHz and 14.8 – 16.4 GHz respectively. Figure 4 shows the gain of the proposed antenna. The graph has been plotted in between the Frequency (GHz) and Gain (dB).

4. Conclusion

A compact and simple dual circularly polarized antenna is designed. Many designs are proposed to achieve the circular polarization and here it is a simple structure through which circular polarization can be achieved easily in the frequency range of Ku band application. The structures behave like a circularly polarized antenna which is a dual band. The S11 plot is also being generated which gives a good result of the notch going up to a deep of -23.74 dB at 12.7 GHz frequency. Overally we can conclude that the designed antenna is compact in size and its application can be visualized in the high frequency range like Ku and K band.

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