CPW-Fed Compact Circularly Polarized Flexible Antenna for C Band Applications

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***Abstract*—In this paper, a simple, and compact CPW-fed circularly polarized antenna is presented. The proposed antenna consists of a modified "S" shaped patch which has slots in three different places along with a slot in the ground plane. These slots contribute in increasing the bandwidth of the axial ratio. The antenna has a 3 dB axial ratio bandwidth of 10.47% (4.07 GHz-4.52 GHz) and an impedance bandwidth of 17.53% (3.8 GHz - 4.53 GHz) covering the full region of axial ratio band. Moreover, this antenna is designed using PET paper which makes it flexible in nature and the first flexible antenna in discussed frequency range to the best of author's knowledge.**

I. Introduction

Demand for flexible electronics is projected to be around 50 billion US dollar globally by 2027 according to a recent market research. Antenna being an important part of modern devices, is extensively researched to make it compatible for flexible devices [1], [2]. However, most of these designs are linearly polarized antenna which are least preferred for non-stationary applications. Circularly polarized (CP) antennas provide advantages like low polarization mismatch loss, reduced multi-path interference or fading which limits 'Faraday rotation' effect, and less constraints for orientation in devices which result in enhancement of efficiency and reliability of moving wireless communication devices. Mainly dual feeding (uses complex structures like wilkinson power divider, ring hybrid coupler, and T junction power splitter etc.), and single feeding (CPW-feeding) are used for realizing CP antennas. Though dual feeding techniques offer wide bandwidth, CPW-feeding techniques are simple, compact, and easier to fabricate. In [3], an inkjet-printed circularly polarized antenna array is proposed for 7.4 - 8.4 GHz. This design is bigger in size and is not in our band of interest. In [4], a CP antenna is proposed using Rogers Ultralam 3850 substrate for 5.2 GHz, which has very narrow bandwidth to work with. In [5], a flexible CP antenna is proposed for 5.73 - 5.95 GHz using Panasonic R-F 770 substrate and foam where CP radiation is realized by putting two pairs of shorting pins on a regular rectangular patch antenna. This structure is complex to fabricate and have a relatively narrow bandwidth. In this paper, a CP antenna is proposed for 4.07 - 4.52 GHz axial ratio bandwidth (ARBW) by using inkjet printing on a PET paper layer. The antenna is 31 mm x 38 mm x 0.135 mm in size making it a very compact structure. Along with that, CPW-feeding is used to make the structure very simple to fabricate.

II. Antenna Design

The top layer of the proposed antenna is shown in Figure 1. Patch of the antenna is modified "S" shape with CPW-feeding. This design is printed over a PET paper which has a

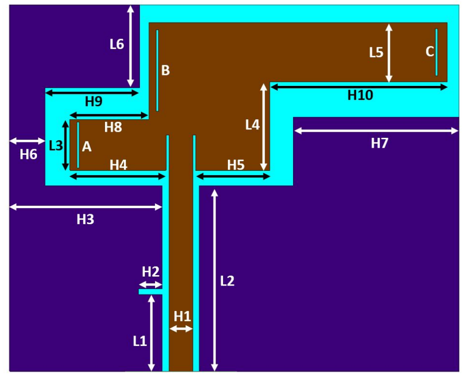

Fig. 1: Design of the proposed antenna. Values of optimized parameters are: H1 = 2 mm, H2 = 2 mm, H3 = 12.9 mm, H4 = 8.12 mm, H5 = 6.28 mm, H6 = 3 mm, H7 = 14 mm, H8 = 6.67 mm, H9 = 10 mm, H10 = 15 mm, L1 = 6.5 mm, L2 = 15.7 mm, L3 = 4.3 mm, L4 = 7.5 mm, L5 = 5 mm, L6 = 7 mm.

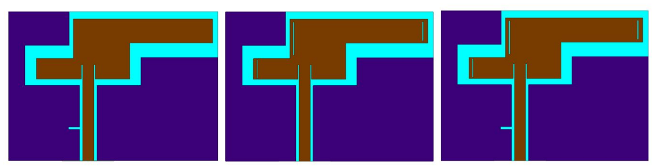

Fig. 2: Design evolution of the proposed antenna.

thickness of 0.135 mm, loss tangent of 0.022 and permittivity of 3.2. The length of the antenna is 31 mm and width is 38 mm. Antenna design is upgraded step by step which is shown in Figure 2. Firstly, a slot with a width of 0.5mm is introduced in the ground plane. The location of the slot is left side of the feed line. The gap between the ground plane and the feed line is 0.57 mm in both sides. Three slots are inserted in the patch of the antenna which are marked in Figure 1. All of these slots has same width of 0.2 mm while slot 'A', 'B', and 'C' has length of 3.9 mm, 6.9 mm, and 4 mm respectively. Inset feeding is used in this antenna with a distance of 3 mm from the end. Other parameters are optimized using ANSYS HFSS and shown in Figure 1.

III. Simulated Results

Figure 3(a) shows the S11 parameter and Figure 3(b) shows the axial ratio of the proposed antenna. With the patch slot only, S11 parameter maintains a bandwidth of 73 MHz from 3.88 GHz to 4.61 GHz. However, ARBW is 20 MHz (4.21 GHz - 4.41 GHz). To increase the ARBW, ground slot is introduced and patch slot is removed. S11 parameter has a bandwidth of 71 MHz from 3.85 GHz to 4.56 GHz for this

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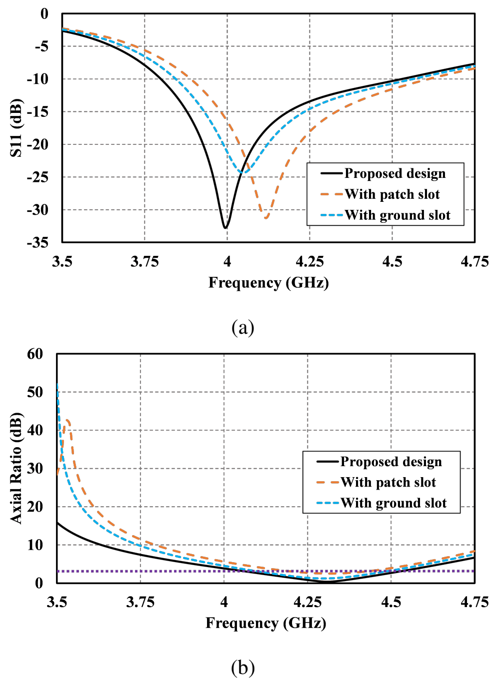

Fig. 3: (a) S11 parameter, (b) Axial ratio of the proposed antenna.

case. ARBW increases to 36 MHz from 4.11 GHz to 4.47 GHz. By applying both patch slot and ground slot, ARBW further increases to 45 MHz (4.07 GHz - 4.52 GHz), whereas S11 maintains a bandwidth of 73 MHz from 3.8 GHz to 4.53 GHz. Figure 4 shows the peak gain and radiation efficiency of the proposed antenna. The antenna has a radiation efficiency over 91% for our discussed bandwidth. Peak gain is over 3.1 dB from 4.07 GHz to 4.52 GHz. Figure 5 shows the simulated radiation pattern for LHCP and RHCP in both XZ (ϕ = 0°) and YZ (ϕ = 90°) plane. It is apparent that pattern for LHCP and RHCP are sufficiently separated (exceeding 20 dB) for broadside direction.

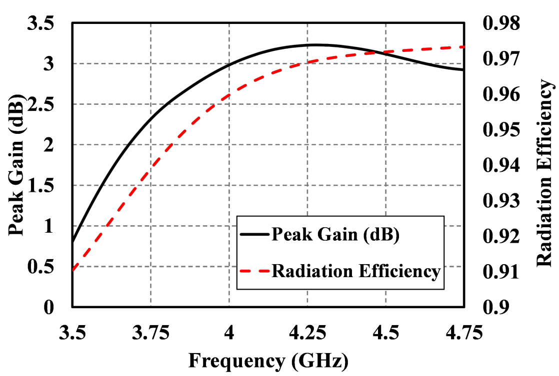

Fig. 4: Peak gain and radiation efficiency of the proposed antenna.

IV. Conclusion

A flexible CP antenna is proposed for applications in C band. Wider ARBW is achieved by using slots in patch and ground, while making it simple for fabrication and integration

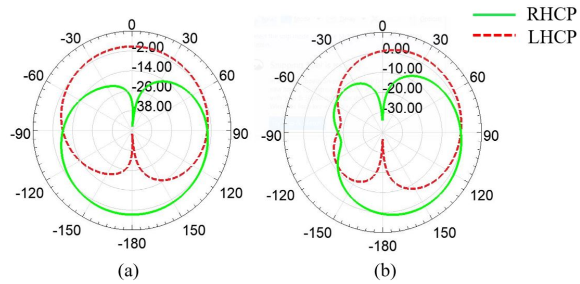

Fig. 5: Radiation pattern of the antenna at 4.3 GHz, where (a) ϕ = 0°, (b) ϕ = 90°. Red line is for LHCP gain and green line is for RHCP gain.

with other circuits by applying CPW-feeding. As antenna is designed on a fully flexible material, it will be useful for any applications that requires structural flexibility. In a future work, the possibility of using it on human body by analysing specific absorption rate will be experimented.

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