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APERTURE COUPLED SLOTTED PATCH ANTENNA FOR DUAL BAND CIRCULARLY POLARIZED RADIATION

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Abstract:
A novel slotted-patch antenna is proposed for dual-band circularly polarized radiation using an aperture coupled feed. The antenna consists of a C/U-shaped slotted-patch radiator with an aperture coupled feeding system. The C/U-shaped slot is embedded on the square patch for dual-band and dual-sense circularly polarized radiation. The measured - 10dB S11 bandwidths for the lower and higher bands are 15% and 3.5%, respectively. The overall antenna size is $0.458\lambda_o \times 0.458\lambda_o \times 0.095\lambda_o$ at 2.5 GHz.

Key words: Slotted patch, square patch, radiation

1. Introduction

The dual-band circularly polarized microstrip antenna design is more complicated than that required for dual-band linear polarized antenna design. There are many methods for dual-band circularly polarized antenna designs but the most of them are working in either right-handed circularly polarized or left-handed circularly polarized radiation. The dual-band dual polarized antenna is challenging task using a single coaxial feed. Dual-band operations of the microstrip antennas have received much attention recently due to multi-band wireless systems. By loading a pair of narrow slots close to the radiating edges of a rectangular microstrip patch [1], dual-band operation of the microstrip antenna can be obtained. For such a dual-band design, the frequency ratio of the two operating frequencies is generally within the range from 1.6 to 2.0 when a suitable slot length is chosen [2]. The CP operation was accomplished by using the U-slot [3] of unequal lengths square microstrip antenna using a coaxial-feed. The asymmetrical U-slot embedded microstrip antenna structure can generate two orthogonal modes for CP radiation; therefore, no extra stubs, notches or chamfering at corners of the square patch are necessary. The overall antenna size was $0.785\lambda_o \times 0.785\lambda_o \times 0.108\lambda_o$ at 2.3GHz. A CPMA with combing slots and patch has been proposed for dual-band operation [4]. They have used power divider to excite the four slots for CP operation. They have been used dual-feed to excited the slots and patch antennas for dual-band CP. In [5], single-layer slits-loaded square microstrips patch antennas were presented for dual-band CP radiation [5]. The aperture coupled feed methods have been attracting much attention because their geometries are suitable for monolithic integration with microwave or millimeter devices. The aperture-coupled structure is also useful for array design [6].

In this paper, a new compact, dual-band, aperture-coupled, patch antenna with combined C\U-shaped slot for circularly polarized operation is proposed. The antenna consists of a C\U-shaped slot, square patch radiator and an aperture-coupled feeding structure. The C\U-shaped slot dimensions are optimized to radiate dual-band circularly polarized radiation. The antenna can achieve dual-band circularly polarized radiation without the need of a hybrid coupler to excite two orthogonal modes with equal magnitude and 90 degrees relative phase shift for both bands. The antenna is designed using the IE3D electromagnetic software and measured to validate the simulation design. The proposed antenna is compact and useful for small wireless devices and systems.

2. Dual-band antenna configuration and design

The cross-sectional view of the proposed microstrip antenna with C\U-shaped slot is shown in Figure 1. This is multilayered antenna structure. The combined C\U-shaped slotted-patch radiator is shown in Figure 2 with detailed design dimensions in mm for dual-band circularly polarized radiation. The 50-Ω microstrip feed line and aperture printed on a RO4003C dielectric substrate (h_1 = 1.524 mm, ε_{r1} = 3.38 and tanδ_1 = 0.002). The microstrip feed line of width (3.6 mm) from the center of the aperture is S_f of 4.5 mm. The W_a = 3.0 mm is the aperture width and L_a = 30 mm is the aperture length. The view of the aperture feeding structure is shown in Figure 3.

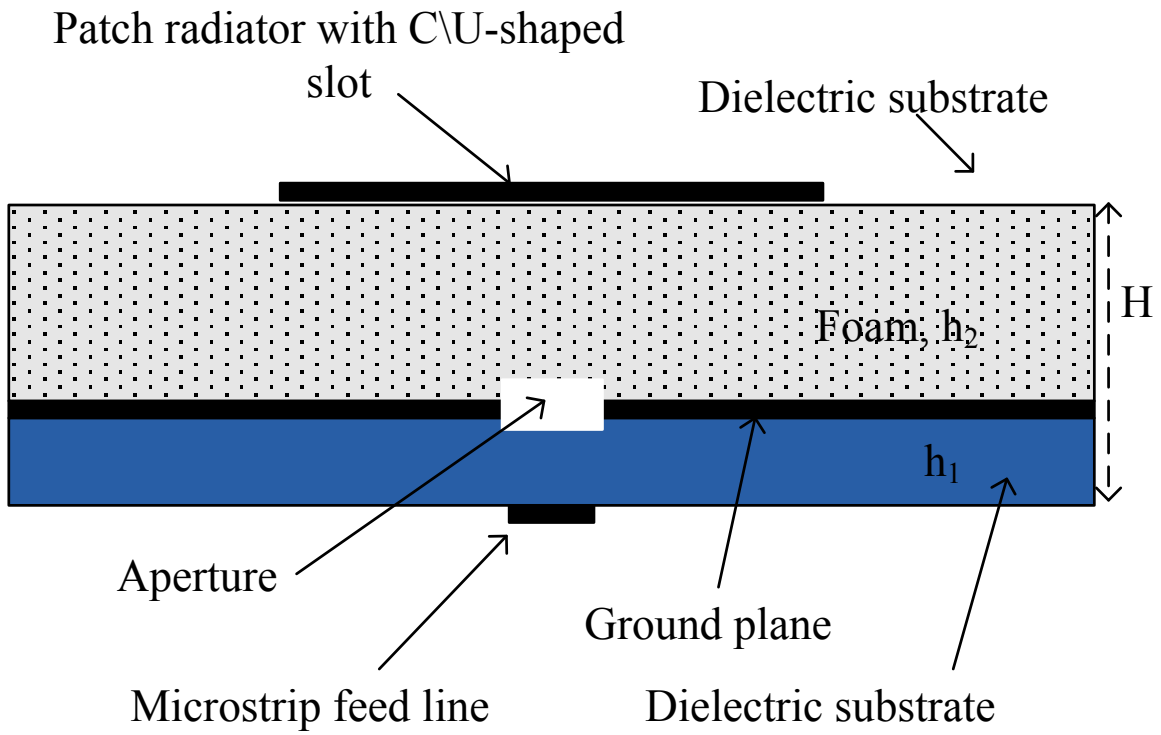


Figure 1. Cross-sectional view of dual-band circularly polarized antenna.

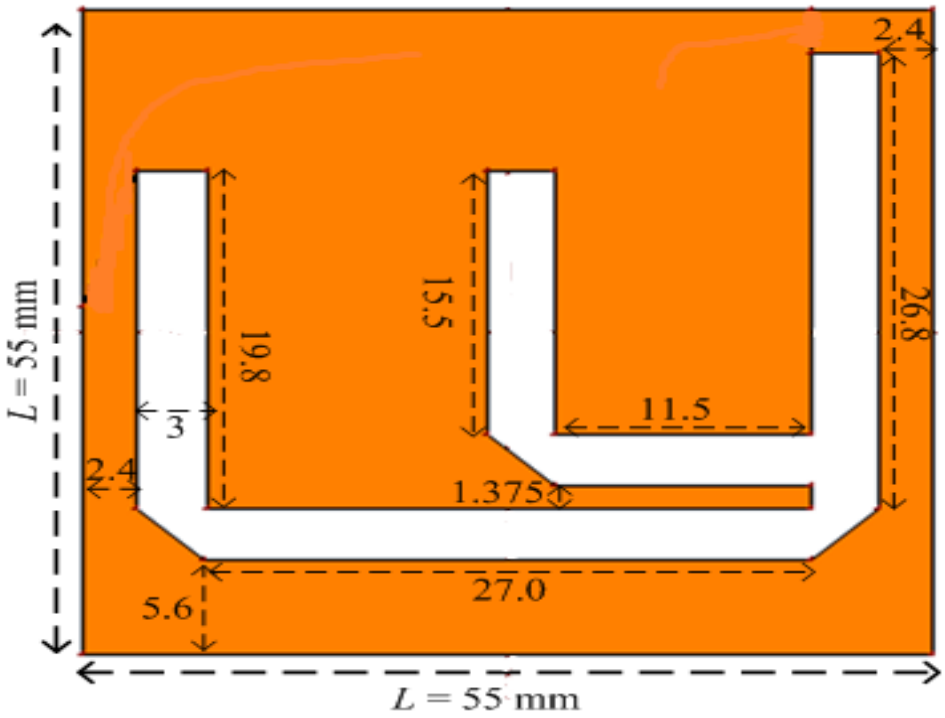


Figure 2. Combined C\U-shaped slotted patch radiator with dimensions in mm.

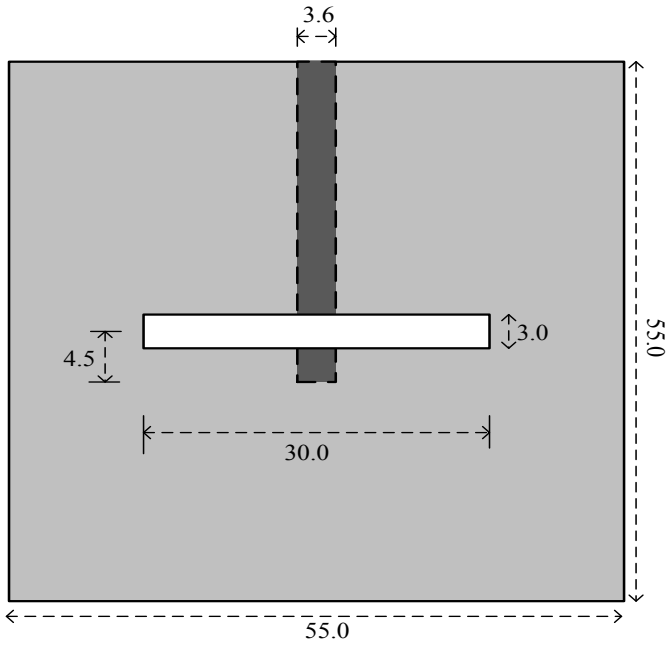


Figure 3. Aperture-coupled feeding system with dimensions in mm.

The square patch with combined C\U-shaped slot has a side length L = 55 mm is designed with copper sheet with thickness of 0.5 mm and placed on Foam layer of height, h_2 = 10 mm. The H = 12.0 mm is total height of the antenna. A narrow slot with width, S_w = 3.0 mm, is embedded in the square patch. The aperture-coupled feed is

located at the center of the combined C\U-shaped slot embedded in the square antenna. The designed antenna in IE3D software is shown in Figure 4.

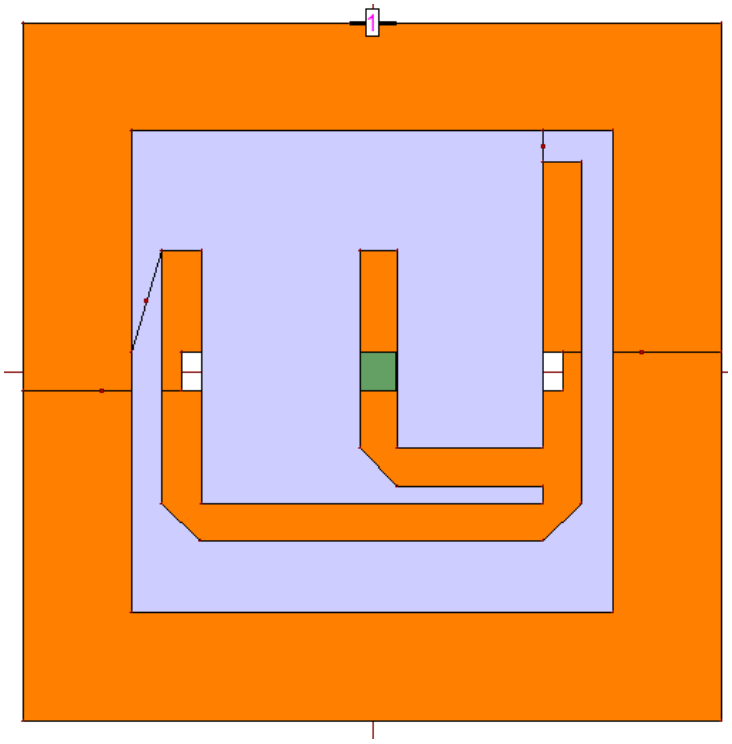


Figure 4. Simulation antenna design model in IE3D.

The combined C\U-shaped slot dimensions were optimized to achieve the dual-band circularly polarized radiation.

3. Optimized Results of Antenna

After multiple modifications and simulations, the required antenna parameters set for the project were obtained, for the combined C\U-shaped slotted patch antenna design.The S11/return loss is shown in Figure 5 with frequency and shows the dual-band operation of the antenna at 2.30 and 2.65 GHz. The realized gain is more than 6.0 dBi in both bands and shown in Figure 6 with frequency. The 3-D radiation patterns of the antenna are illustrated in Figure 7.

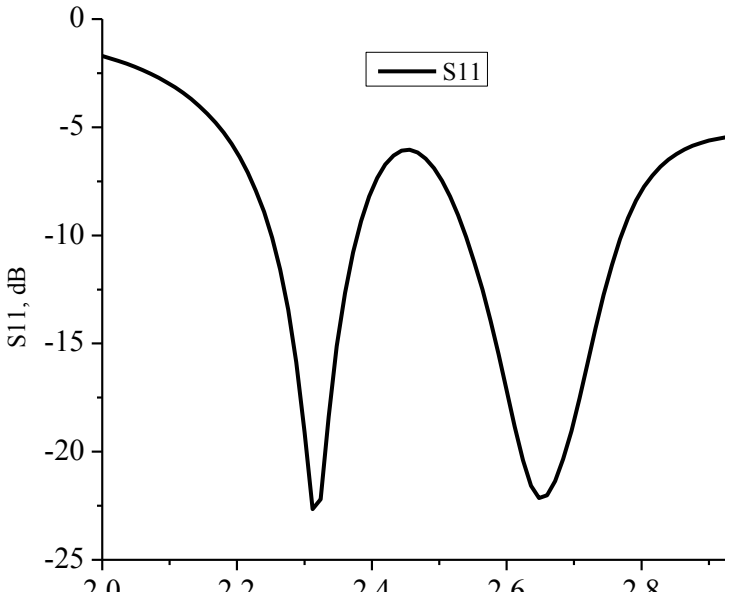


Figure 5. S11 with frequency of the dual-band circularly polarized antenna

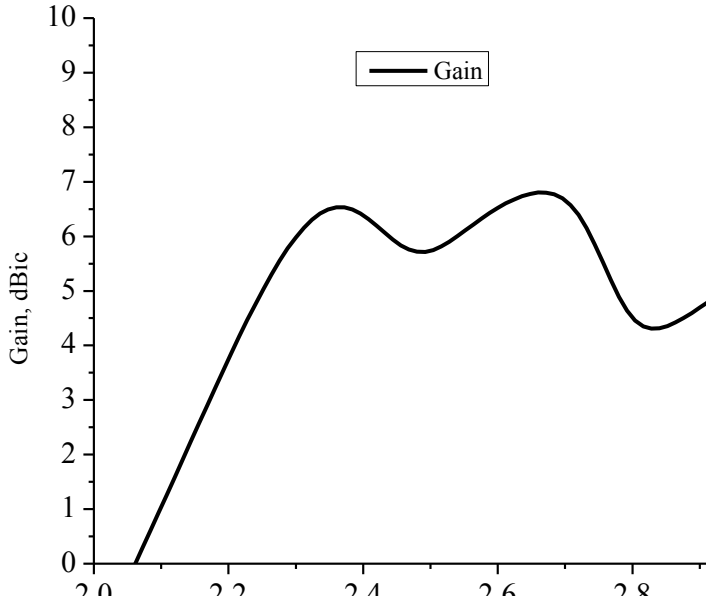
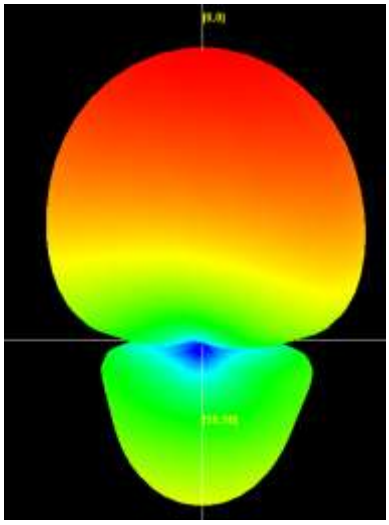
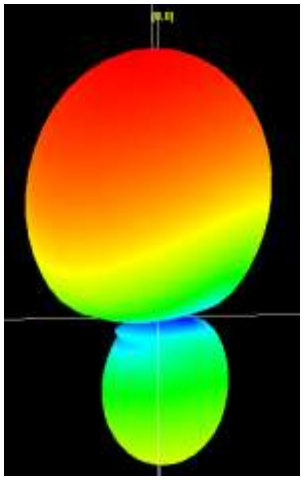


Figure 6: Gain with frequency of the dual-band circularly polarized antenna



Radiation pattern at frequency of 2.3 GHz



Radiation pattern at frequency of 2.7 GHz

Figure 7. 3-D radiation patterns for dual frequency band.

I. 4. MEASURED RESULTS AND DISCUSSIONS

The initial structure was for the tap-shaped antenna was supposed to be cut out on a layer of copper on top of the rest of the structure, the layer of foam followed by the ground-plane (copper), then on a substrate layer and then finally, the transmission line. The fabricated prototype antenna is illustrated in Figure 8.

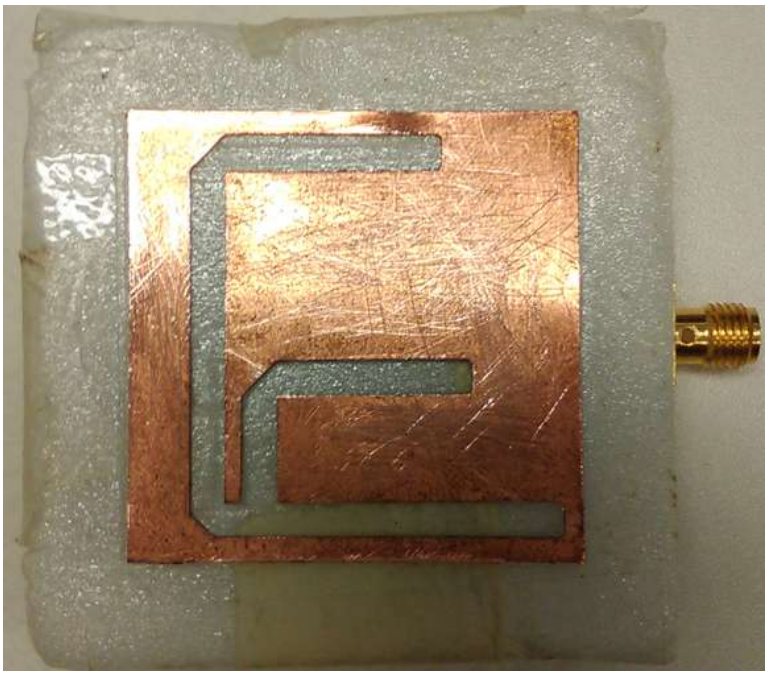
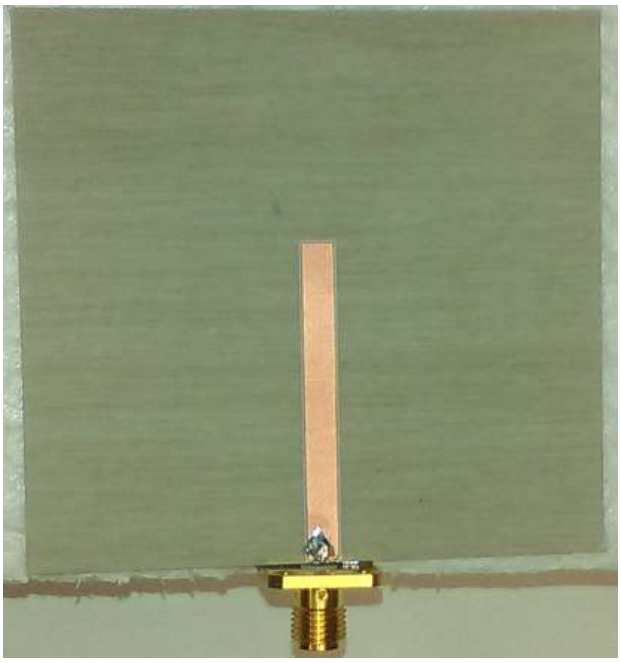


Figure 8: Fabricated dual-band circularly polarized combined C\U-shaped slotted patch antenna.

Note that the ground plane and transmission line are fabricated on a single 2-sided copper layer substrate. The Figure 1 below shows the top and bottom view of the same piece of substrate.



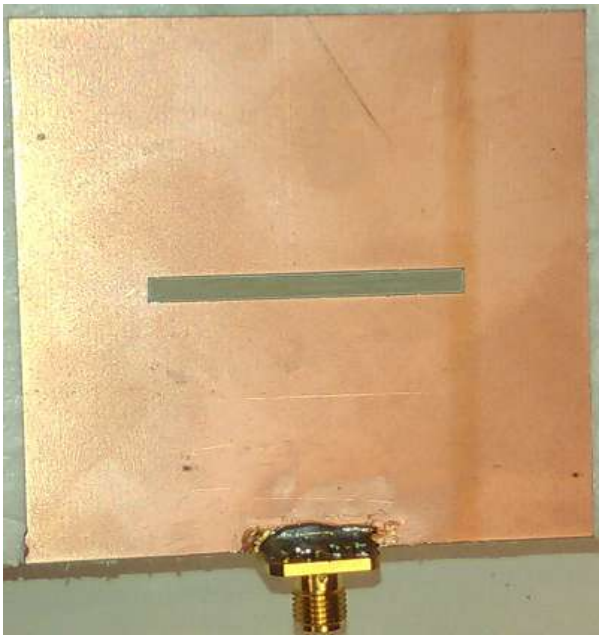


Figure 9: Fabricated aperture coupled feeding system: microstrip Line and aperture in ground plane

After the fabrication of the antenna, the antenna parameters were measured using the Vector Network Analyzer. The measured S11/return loss is shown in Figure 10.

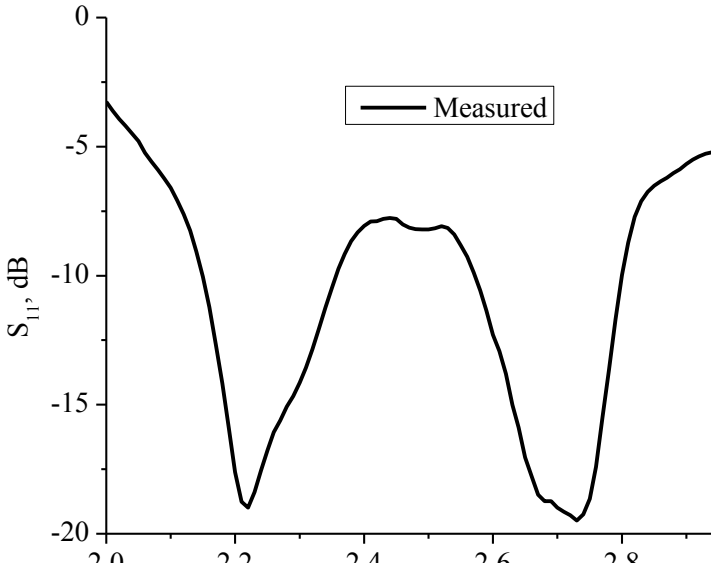


Figure 10: Measured S_{11} with frequency of the antenna.

II. 5. CONCLUSION

A novel C/U-shaped slotted patch antenna using aperture coupled feeding has been demonstrated for dual band applications. This antenna can generates the dual-band radiations and useful for dual-band wireless systems. The antenna was designed, fabricated and measured. The proposed antenna is useful for wireless communication systems.

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