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Original scientific paper

DESIGN AND DEVELOPMENT OF DUAL BAND CPW FED ANTENNA FOR WLAN AND WIFI APPLICATIONS

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Abstract. *A dual band coplanar waveguide (CPW) fed antenna is constructed, analyzed, and designed for WLAN and WiFi applications in this paper. The antenna has a compact size of 25 × 25 × 1.5 mm^3. The antenna structure comprises of a slotted radiating patch over FR4 substrate surrounded by staircase shaped ground plane. As part of the analysis of the characteristics parameters such as the return loss, VSWR, and radiation pattern, HFSS 11.1 is utilized. There is a resonance at two frequencies of 3.3 GHz and 5.82 GHz, with an upper frequency bandwidth of 1.89 GHz. In addition to the antenna design, measurement results are presented. Mobile handheld devices can use the proposed antenna for WLAN and WiFi applications that operate in ISM bands.*

Key words: *CPW fed, patch antenna, ultra-wide band, WiFi, WLAN*

1. INTRODUCTION

Miniaturized planar antennas are important in portable wireless communication devices. By using a single antenna that resonates at multiple frequencies, the number of antennas, cost, and size of a device can be reduced. An unlicensed ultra-wideband (UWB) system has been developed to support wireless communication over short distances and with high data rates. For ultra-wideband (UWB) communication systems, the Federal Communication Commission (FCC) has approved a frequency range of 3.1 to 10.6 GHz [1, 2]. Due to its advantages of small power consumption, low cost, and highly safe communication, ultra-wideband technology is an ideal candidate for current generation communication systems [3, 4]. In microwave and millimeter wave applications, CPW antennas are attractive candidates due to their low dispersion, low radiation losses, wide bandwidth, low cost, etc. [5]. For microwave applications, it provides easy fabrication. With CPW, higher frequencies have significantly fewer losses than with microstrip feed. The

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reason behind low losses is the existence of field existing outside the dielectric [6]. Various slots created on patch and ground plane can make antenna resonate at multiple bands [7]. The CPW line is etched on the conducting ground plane of microstrip patch antenna and coupled using slot [8]. CPW fed MIMO antenna with ultra-wideband response from 3 – 11 GHz for wireless applications is discussed in [9]. These CPW fed antennas meet the requirements of compact wireless devices such as omnidirectional patterns, lightweight, and low cost [10, 11].

Increasingly, planar antennas with wideband responses are being used in handheld devices [12]. A dual band monopole antenna with CPW fed resonating in ISM band suitable for IoT applications is described in [13]. The presented paper proposes a CPW fed planar antenna that can be used in WLAN and WiFi based wireless networks. A CPW antenna is a promising candidate for microwave and millimeter wave applications because it has unique features such as a narrow dispersion range, low radiation losses, and a wide bandwidth at a low price.

The design and construction of the proposed antenna is defined in Section 2. In Section 3, a parametric study to find out the optimized dimensions of the proposed design is presented. Fabrication and measurement results are included in Section 4. Finally, conclusion and future scope of work are discussed in Section 5.

2. Antenna Configuration and Design Methodology

With the help of slots antenna can be made to resonate at more than one band as well as bandwidth is increased. This antenna consists of a square shaped FR4 substrate (25 × 25 × 1.5 mm^3) over which a rectangular shaped slotted conducting patch is etched. The radiating patch is surrounded by a staircase-shaped ground plane. A ground plane is designed in such a way that the area surrounding the patch is utilized as much as possible. Fig. 1 illustrates the different dimensions of the patch and ground plane.

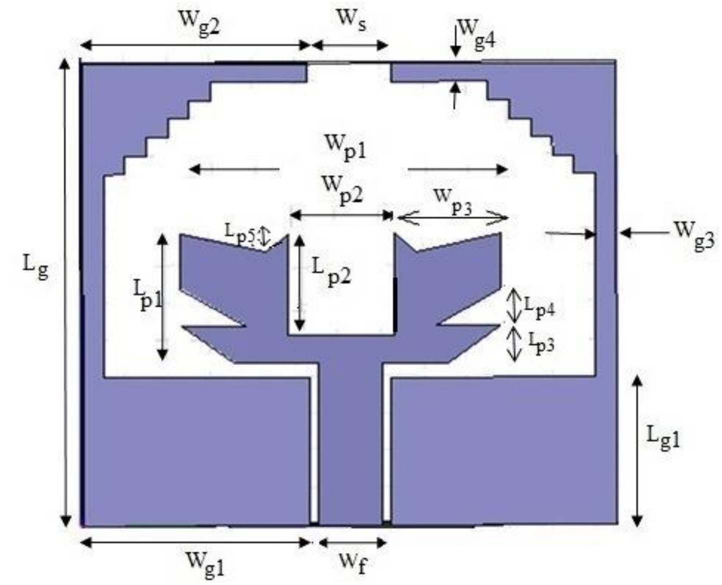


Fig. 1 Structure of CPW fed slotted antenna

3. Simulation and Analysis

Parametric studies are performed using HFSS 11.1 to optimize antenna design parameters. As shown in Figs 2 – 3 ground plane width and patch length affect antenna performance. The feed width (W_f) and location has impact on impedance matching of antenna. It also affects both the resonating frequencies and bandwidth of the antenna. As the designed antenna is symmetrical in shape, feedline is placed at the center so that 50 ohms impedance matching can be achieved. To see the impact of antenna dimensions on resonating frequencies a parametric study is carried out for two parameters. In Fig. 2 effect of ground plane width Ws on both resonating frequencies is shown. It is shown that two major bands can be obtained by keeping the width at 4 mm. The return loss values are -17 dB and -17.1 dB at 3.8 GHz and 5.9 GHz respectively.

As the slot length L_{p2} increases, the corresponding decrease in return loss is found as given in Fig. 3. Two significant bands are observed by keeping patch length equal to 5.5 mm.

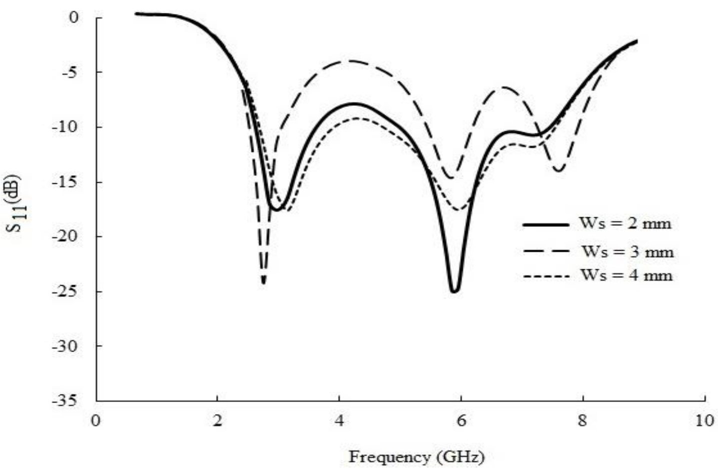


Fig. 2 Variation of return loss with a ground plane width

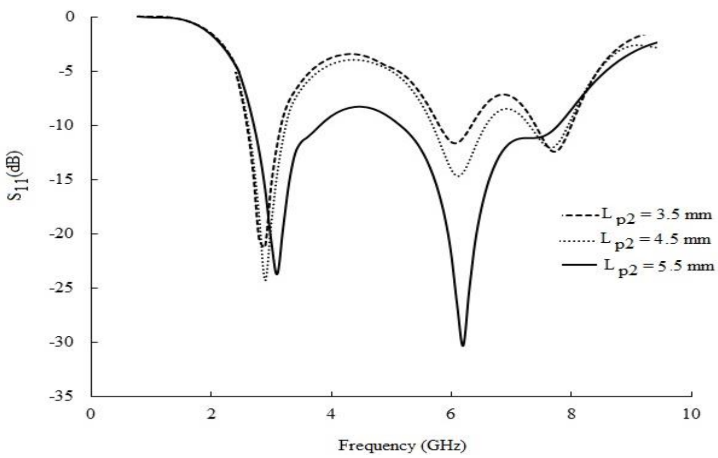


Fig. 3 Variation of return loss with patch length

By designing this antenna using optimized values dual bands are obtained as presented in Fig. 9. The values of various physical dimensions of substrate, radiating patch and ground plane are mentioned in Table 1.

Table 1 Antenna Physical Dimensions

Parameters	Unit (mm)
L_g	25
L_{p1}	7
L_{g1}	7
W_{p1}	15
W_{p2}	5
W_{g1}	10.2
W_{g2}	10.5
W_{g3}	0.8
W_{g4}	1
W_f	4
W_s	4
L_{p3}	2.5
L_{p4}	2
L_{p5}	1
W_{p3}	5

The simulated return losses are approximate -20.5 dB and -31.3 dB at 2.8 GHz and 5.9 GHz respectively. The bandwidths of lower and upper bands are 500 MHz and 1.5 GHz respectively.

The simulated VSWR values are 1.7 and 1.5 at 2.8 GHz and 5.9 GHz respectively as shown in Fig. 4. These values show that proper impedance matching is achieved.

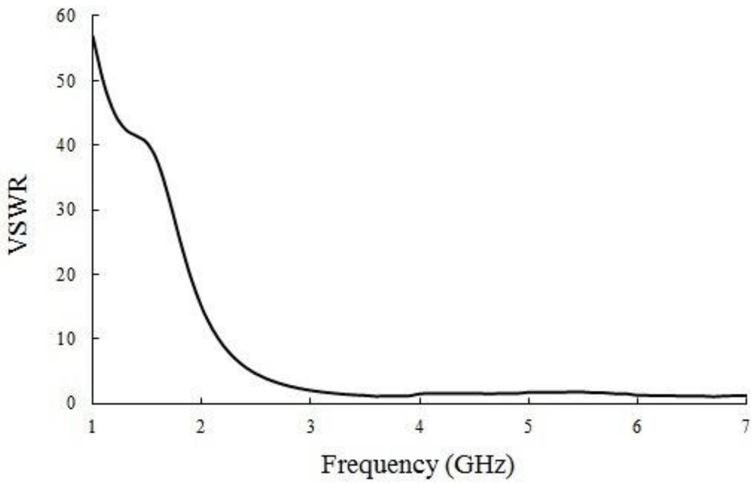
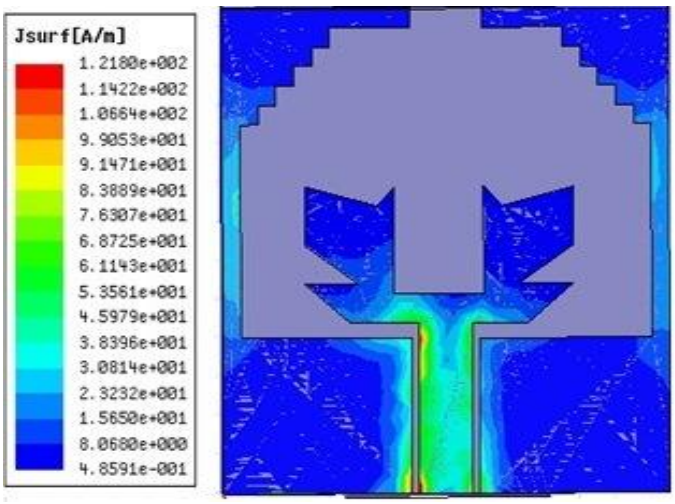
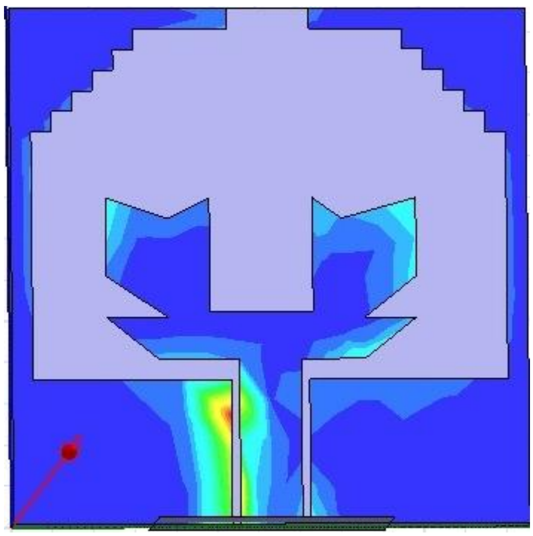


Fig. 4 Simulated VSWR versus frequency curve

As depicted in Fig 5 current distribution at 2.8 GHz is concentrated on feed, ground plane and the lower portion of the patch. In rest of the radiating area, an almost constant distribution is found.



(a)



(b)

Fig. 5 Simulated Current density distribution curve (a) 2.8 GHz and (b) 5.9 GHz

The impedance curve in Fig. 6 displays that at 2.8 GHz, real part of the impedance is around 30 ohms. The imaginary part of the impedance is negative which shows that it is capacitive. At 5.9 GHz real value of impedance is 57 ohms. This shows proper impedance matching at these points.

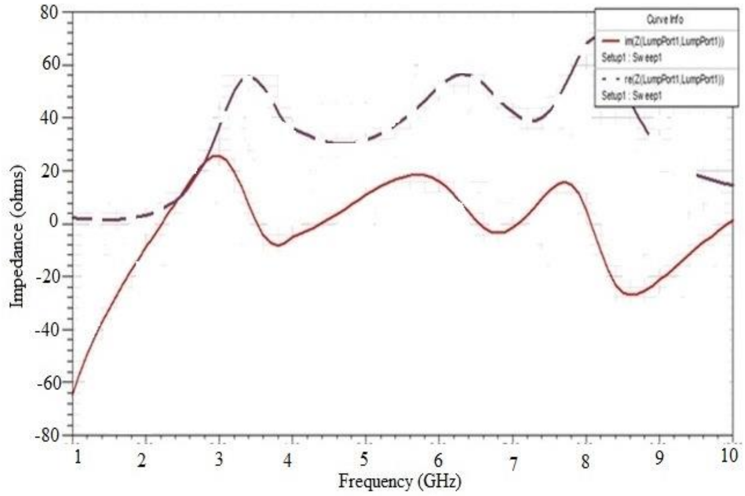


Fig. 6 Simulated input impedance response curve

4. FABRICATION AND TEST RESULTS

The designed antenna was fabricated over an FR4 substrate. The picture of the fabricated antenna is displayed in Fig. 7.

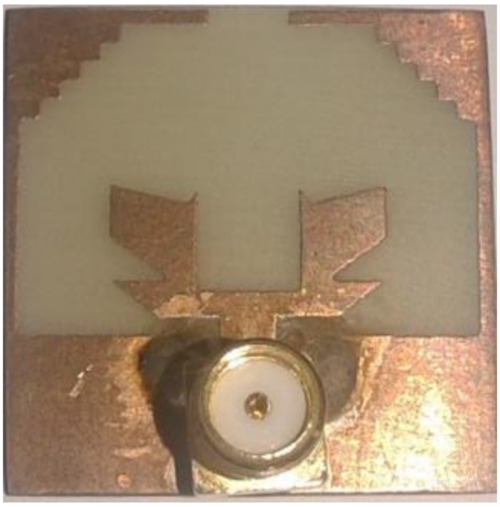


Fig. 7 Fabricated antenna

Return loss and VSWR were tested using Rohde & Schwarz ZVA40 Vector Network Analyzer. It is found that the designed antenna gives dual-band performance as shown in Fig. 8. Return loss values are -29.27 dB and -23.06 dB at 3.3 GHz and 5.82 GHz respectively. The bandwidth of lower band is 0.49 GHz and upper band is 1.89 GHz. Although it is a dual band antenna with upper resonating frequency has a bandwidth of 1.89 GHz which can be considered as a broadband response. This antenna is found useful for WLAN application.

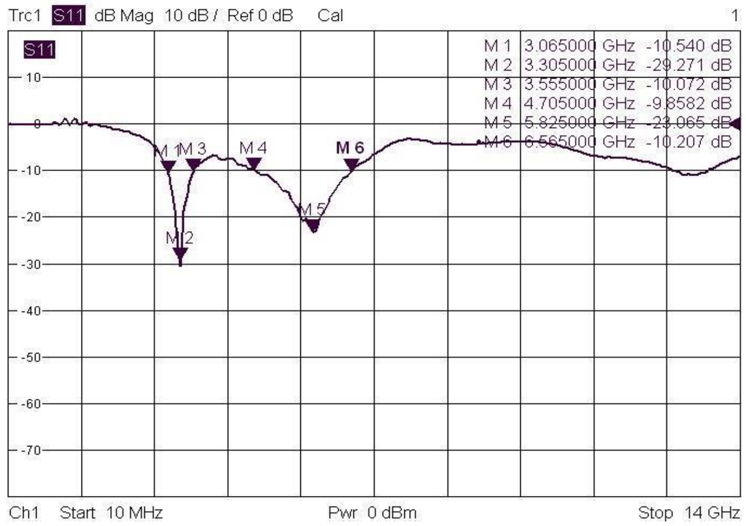


Fig. 8 Measured return loss curve

The discrepancy between the measured and simulated results is mainly due to the slight impedance mismatching in the lower frequency band. As shown in Fig. 6 at 2.8 GHz, obtained real part of the impedance is around 30 ohms in simulation, whereas at the time of measurement, 50 ohms impedance matching was used. At higher frequency of 5.9 GHz real value of impedance is 57 ohms which is close to the 50 ohms. Hence a significant discrepancy occurs only in the lower frequency band as shown in Fig. 9.

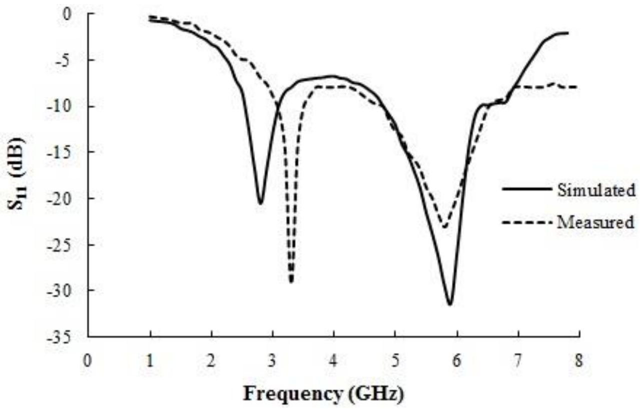


Fig. 9 Simulated and Measured return loss curve

The measured VSWR values are 1.08 and 1.17 at 3.3 GHz and 5.82 GHz respectively as presented in Fig. 10. These values are desirable and close to the ideal values.

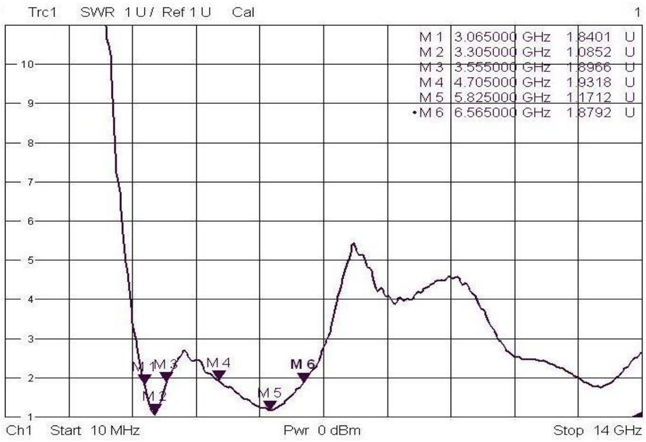


Fig. 10 Measured VSWR curve

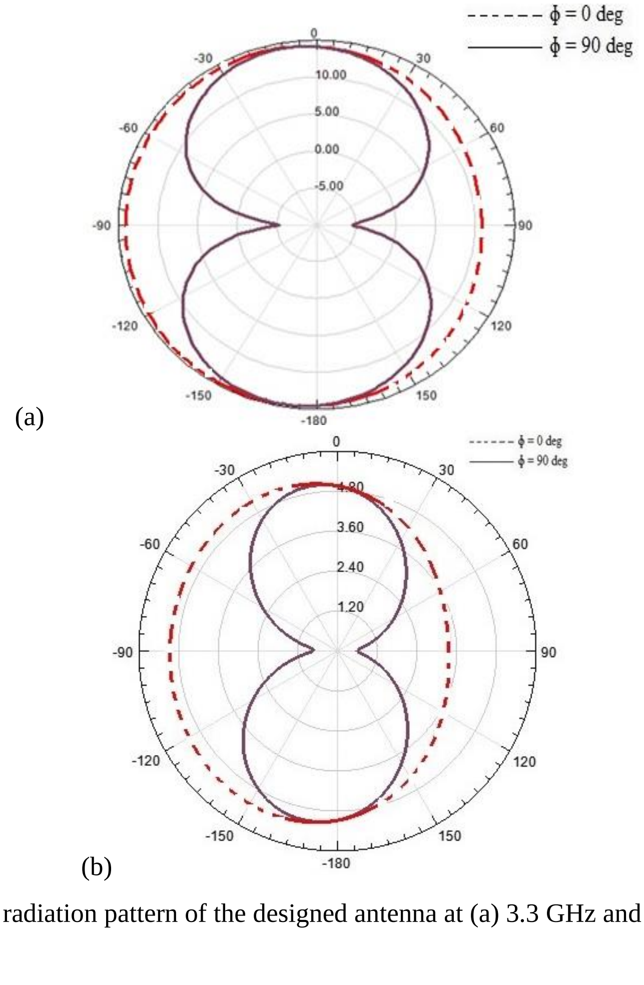


Fig. 11 The radiation pattern of the designed antenna at (a) 3.3 GHz and (b) 5.82 GHz

The obtained, radiation patterns are almost omnidirectional, which are suitable for mobile communication as presented in Fig. 11. Comparison of presented work with similar antennas resonating in dual bands from literature is presented is Table 2. The antenna achieves compactness and wider bandwidth than other antennas.

Table 2 Comparison of proposed antenna with previous works

Ref	Area (mm)	Thickness (mm)	Resonating bands	Bandwidth
[14]	50 × 50	1.6	2.41 GHz 5.8 GHz	53.6 MHz 200.4 MHz
[15]	35 × 39	1.6	2.63 GHz 5.45 GHz	1.45 GHz 0.7 GHz
[16]	97.48 × 80	0.5	2.39 GHz 3.77 GHz	0.41 GHz 0.6 GHz
[17]	44 × 41	1.6	2.4 GHz 5.4 GHz	59.9 MHz 202.6 MHz
Present	25 × 25	1.5	3.3 GHz 5.82 GHz	0.49 GHz 1.89 GHz

5. Conclusion

In this work, a compact square shaped CPW fed antenna, with staircase ground plane has been proposed, designed, fabricated and tested. The designed antenna resonates at two different frequencies viz. 3.3 GHz and 5.82 GHz. The bandwidth of upper frequency band is 1.89 GHz. An attempt may be made in the future to improve the bandwidth of the antenna. The radiation characteristics and compactness make this antenna suitable for WLAN and WiFi applications in portable devices.

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