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RESEARCH PAPER

New low-cost broadband CPW-fed planar antenna

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The narrow bandwidth of microstrip antennas is one of the most important features that restrict its wide usage. This paper presents a new coplanar waveguide-fed compact rectangular microstrip antenna with the improvement of the bandwidth using the slot geometry and cutting rectangular periodic edges for the patch radiator. To develop this structure, we have conducted many optimization and investigation using Momentum Software integrated into ADS "Advanced Design System" and comparison of the results with CST Microwave Studio. The comparison between the simulation and measurement results permits to validate the final achieved antenna with an improvement of the bandwidth. This antenna has wide matching input impedance ranging from 1.7 to 3.5 GHz with a return loss less than −10 dB, corresponding to bandwidth 69.7% at 2.6 GHz as a frequency center. The antenna achieved is a low cost, planar, and easy to be fabricated, thus promising for multiple applications in wireless communication systems. Details of the proposed antenna design and both simulated and experimental results are described and discussed.

Keywords: Microstrip antenna, CPW-fed, Slot technique, Edge, Improvement

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I. INTRODUCTION

Microstrip patch antennas are extremely attractive candidates for uses in many wireless applications due to their interesting features, such as compatibility with monolithic microwave-integrated circuit (MMIC), light weight, small volume, low-cost device, low profile, stable radiation, and easy fabrication. On the contrary the narrow bandwidth is a major obstacle associated with a microstrip antenna in wide band applications. So, the impedance bandwidth of the basic structures of the microstrip antennas is only a few percent 2–5% [1–2]. Therefore, the needs of broadband antennas have pushed research efforts to meet the development of the antenna structure broadband or the improvement of the frequency bandwidth to support multiple wireless system application, especially for applications of multimedia communications and wireless radio technologies to greater capacities broadband service.

Several ways to enlarge the operating bandwidth frequency have been studied [6–13]. In this work, a novel rectangular broadband antenna design with the improvement of the bandwidth is proposed. Design and conception methodologies allow us to achieve a rectangular antenna which radiates in the desired broadband frequency range. The proposed antenna consists of a slot and a matching coplanar waveguide (CPW)-fed. The CPW mechanism, geometry antenna, and slot techniques also have many advantages over microstrip type to efficiently control the characteristics of the impedance, and to ease the integration with active devices. The details of the design considerations for achieving broadband antenna and both simulated and experimental results are presented and discussed.

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II. ANTENNA DESIGN

The geometry and configuration of the CPW-fed slot rectangular antenna is shown in Fig. 1(d). The proposed antenna is implemented on a low-cost FR4 substrate with a relative permittivity $\varepsilon_r = 4.4$, thickness of $h = 1.6$ mm, and total area of 27×42 mm^2. The rectangular microstrip antenna is fed by using a 50 Ω impedance CPW that has a central strip having as width $W_f = 3.2$ mm, the gap between the central feed line and the ground is fixed at $S = 0.25$ mm. The optimization parameters design is done using momentum electromagnetic software integrated into Advanced Design System (ADS), which contains different techniques and calculation methods [14]. For comparison, we have conducted another study using CST Microwave Studio in frequency domain where the numerical analysis is based on FIT [15]

The final dimensions of the antenna structure are listed in Table 1.

The aimed goal of this study is to widen the narrow bandwidth of the basic rectangular patch antenna to covering

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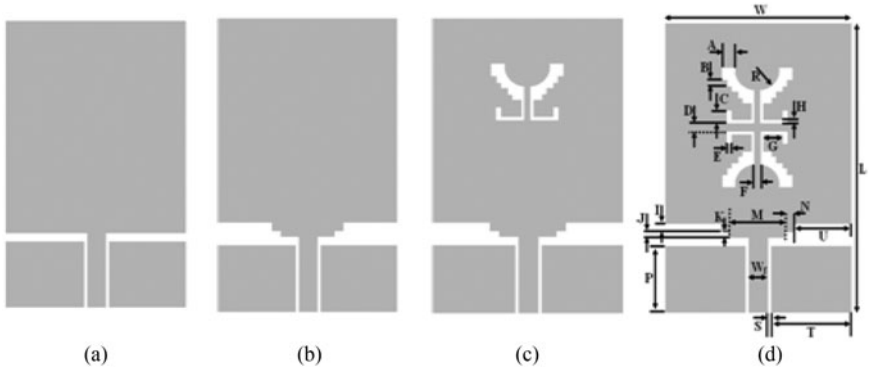


Fig. 1. Design evolution of the final proposed antenna.

Table 1. Optimized dimensions in mm.

Parameter	Value	Parameter	Value	Parameter	Value	Parameter	Value
A	2.1	G	3.2	L	42	R	4.1
B	1	H	0.4	M	8	T	11.5
C	2.1	I	1.5	N	1.5	U	9
D	1.5	J	1	P	9	W	27
E	0.75	K	1	F	1.5		

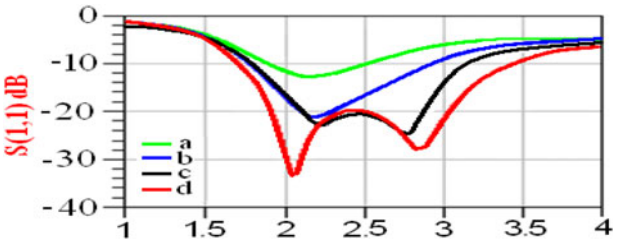


Fig. 2. Simulated return loss results versus frequency in ADS.

Table 2. The bandwidths of the proposed antenna for different structures.

	Bandwidth	Impedance bandwidth (%)
a	1.85–2.5 GHz/BW = 0.65 GHz	29.8
b	1.7–2.95 GHz/BW = 1.25 GHz	53.7
c	1.7–3.15 GHz/BW = 1.45 GHz	61.85
d	1.65–3.45 GHz/BW = 2.25 GHz	69.7

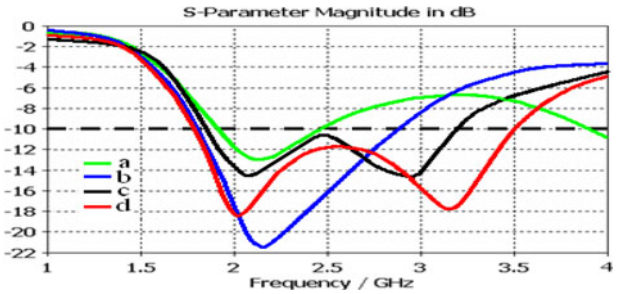


Fig. 3. Simulated return loss results versus frequency in CST.

Table 3. The bandwidths of the proposed antenna.

	Bandwidth	Impedance bandwidth (%)
a	1.85–2.45 GHz/BW = 0.6 GHz	27.9
b	1.7–2.9 GHz/BW = 1.2 GHz	52.1
c	1.71–3.2 GHz/BW = 1.49 GHz	60.94
d	1.7–3.5 GHz/BW = 1.8 GHz	69.3

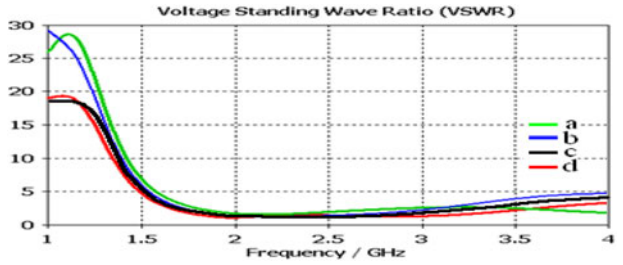


Fig. 4. VSWR versus frequency.

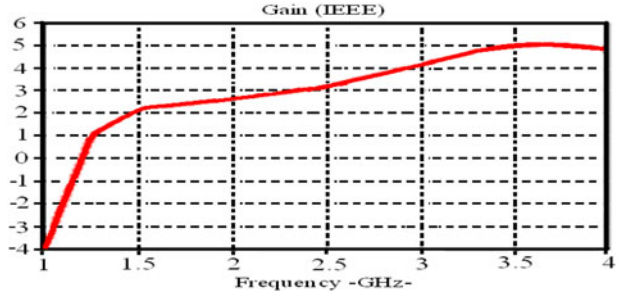


Fig. 5. The gain versus frequency.

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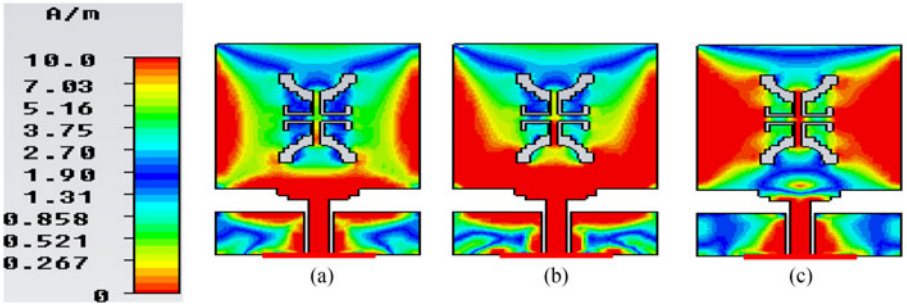


Fig. 6. Simulated surface current distributions of the proposed antenna at (a) 1.8, (b) 2.4, and (c) 3.2 GHz.

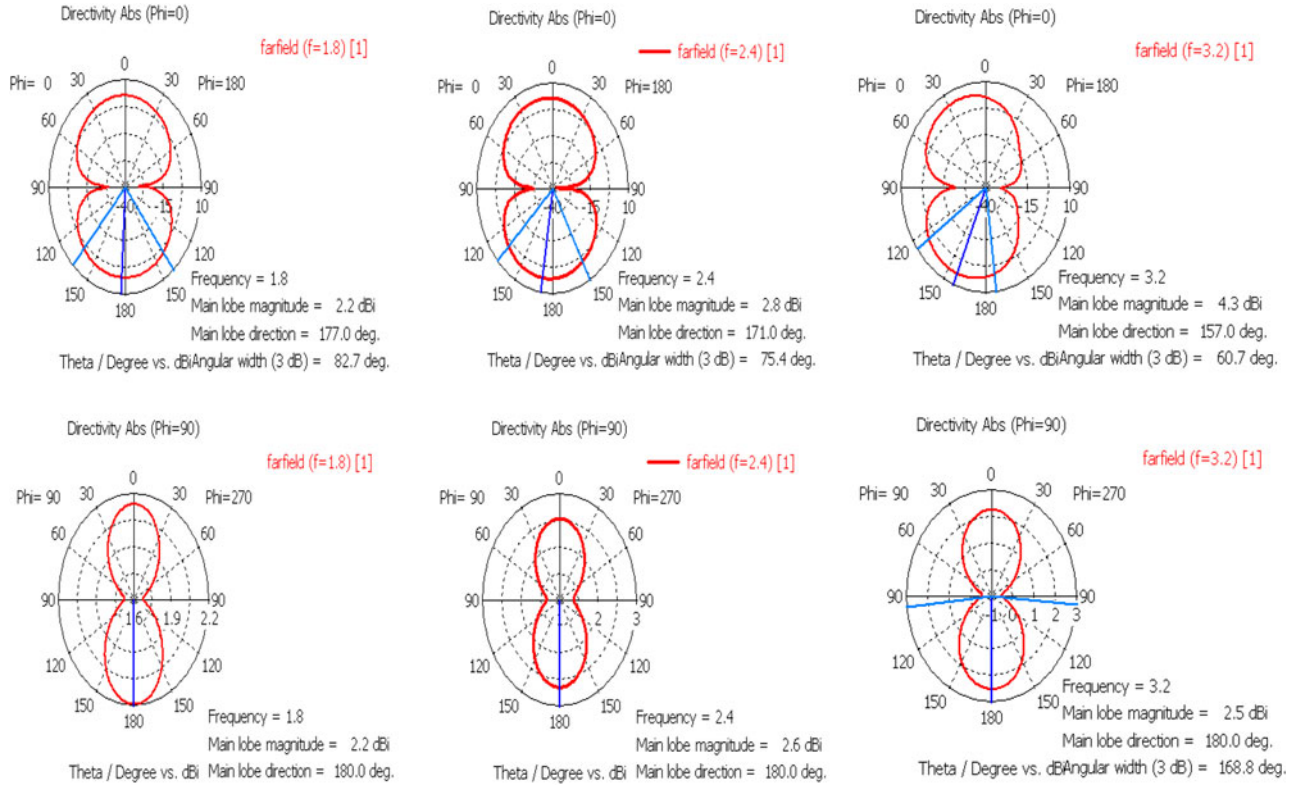


Fig. 7. 2D simulated radiation pattern at 1.8, 2.4, and 3.2 GHz of the proposed antenna.

wideband applications using the optimization and miniaturization techniques integrated into ADS. Therefore, the first step in designing the CPW-fed rectangular antenna with a bandwidth of 600 Mhz as shown in Fig. 2(a). Secondly, cutting a symmetrical periodic rectangular edges have effect on the enhancement of the input impedance bandwidth of the antenna as shown in Fig. 2(b), it can be seen that the return loss was improved. The slot geometry on the radiator patch is another critical design parameter influencing the antenna characteristics. Figs 2(c) and 2(d) show the return loss curves for variation of a symmetrical curved-shaped slot. The final circuit is operating in a large frequency band between 1.7 and 3.5 GHz. It is clear that the improvement of the input impedance bandwidth is due to the presence of the slot notched and the cutting edges. The simulated values are given in Table 2.

For the comparison of the following results, we have made another simulation using CST Microwave Studio. After the simulation, the following results are shown in Fig. 3 and



Fig. 8. Photograph of the fabricated structure with LPKF machine.

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Table 3, respectively. In Figs 2 and 3, it is clearly observed that simulation results on ADS and CST are the closest agreement. A slight difference in the two simulated values is potentially due to the fact that they are based on two different solving algorithms and meshing techniques, it is basically because of the two different numerical methods employed, i.e., MoM by the ADS and FIT by the CST Microwave Studio.

The bandwidth impedance in terms of VSWR is presented in Fig. 4 for the different steps the conception of the antenna structure. The variation of the final proposed antenna gain versus frequency is plotted in Fig. 5. For current distribution it is presented in Fig. 6.

The simulation radiation patterns of the proposed antenna are presented in Fig. 7 at 1.8, 2.4, and 3.2 GHz in the Phi = 0° and Phi = 90° planes.

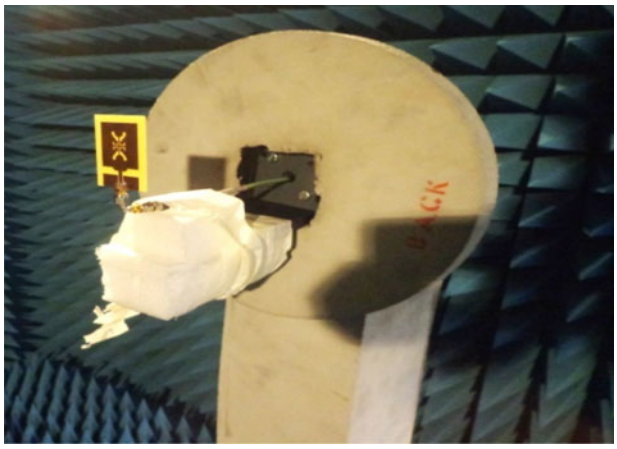


Fig. 9. Photograph of the achieved broadband antenna.

ACHIEVEMENT AND MEASURMENT RESULTS

After the study of the bandwidth enhancement of the narrow bandwidth rectangular antenna using ADS and CST, the final prototype of the investigated broadband antenna structure has been achieved using LPKF machine. The photograph of this antenna is shown in Figs. 8 and 9. The experimental results are done on Vector Network Analyzer (VNA R&S@ZVB20 from Rohde & Schwarz). The simulated and experimental results of the return loss are in good agreement as shown in Fig. 10. This allows the validation of the broadband antenna structure with frequency band from 1.7 to 3.5 GHz which corresponding 69.7%, compared to the narrow band of a classic rectangular patch antenna, which meets the bandwidth requirement for wideband applications such as UMTS, WLAN, WIFI, WMAX, and RFID.

The measured radiation patterns in E- and H-plane at 1.8, 2.4, and 3.2 GHz are presented in Fig. 11.

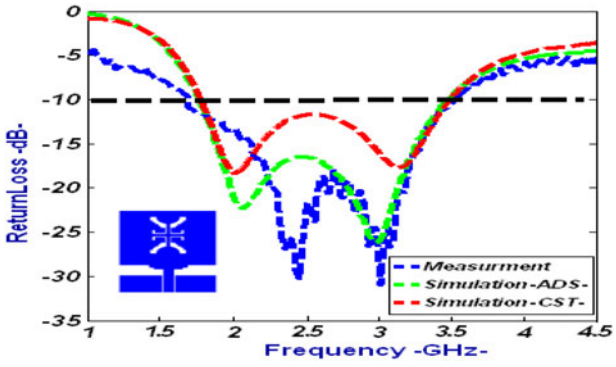


Fig. 10. Comparison of simulated and measured return loss.

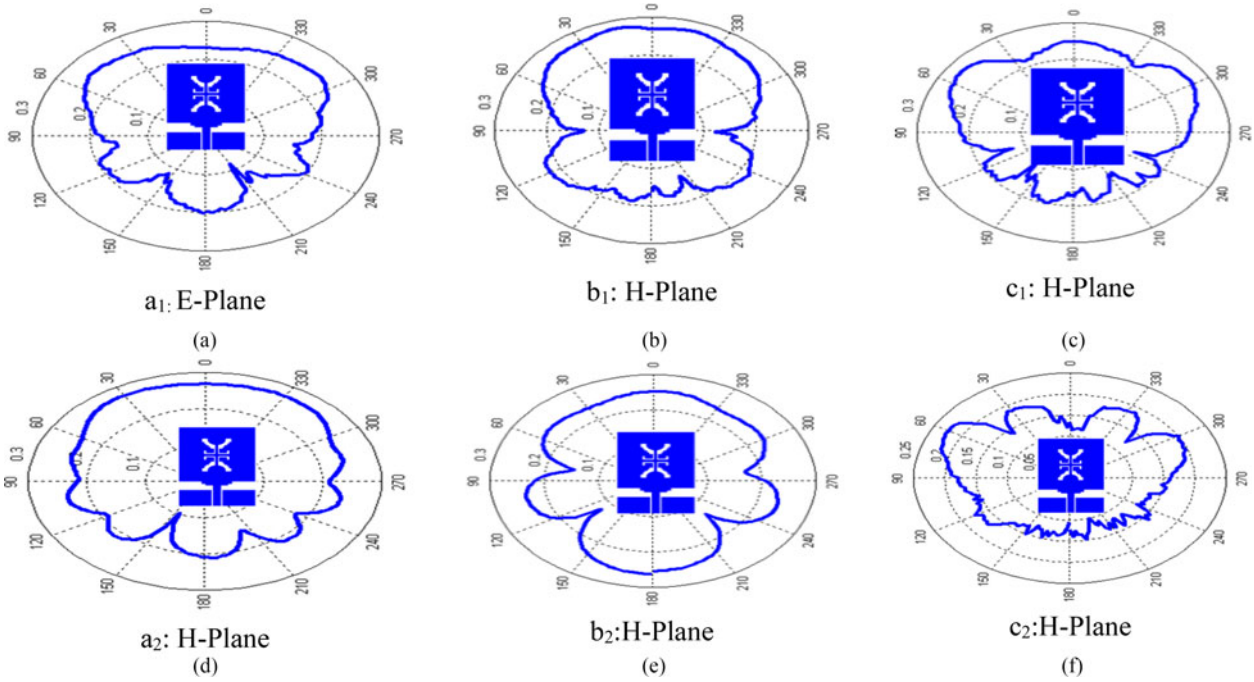


Fig. 11. Radiation pattern at (a_i) 1.8, (b_i) 2.4, and (c_i) 3.2 GHz.

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IV. CONCLUSION

This work has presented a study of a new low-cost coplanar broadband antenna structure using slot technique for bandwidth improvement. The measurement and simulation results are in agreement which validated the rectangular antenna CPW-fed new structure with a bandwidth of 1800 MHz. This achieved antenna is feed with CPW line which is easy to be integrated with passive and active printed circuits broad component for multiple wireless applications such as UMTS, WLAN, WIFI, WMAX, and RFID.

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