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RESEARCH PAPER

A new compact and miniaturized multiband uniplanar CPW-fed Monopole antenna with T-slot inverted for multiple wireless applications

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In this paper, the design of a new compact uniplanar coplanar waveguide-fed antenna for multiband wireless application is presented and investigated. This antenna has a compact size of 25 × 25 mm² and consists of a three parallel stub optimized added on rectangular slot to the radiator patch and T-shaped which inverted in the ground plane. The final prototype antenna designing resonantes at frequency bands (2.4–2.9 GHz), (3.7–5.2 GHz), and (5.7–6 GHz) with a return loss less than −10 dB. Details of the antenna configuration, design, simulation, and experimental results are presented, investigated, and discussed. The compactness, simple feeding technique, and conception of the uniplanar design make it easy to be integrated within devices of multiples wireless applications.

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

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I. INTRODUCTION

In recent years, the technology of wireless communications demand compact and miniaturized uniplanar antennas of broadband or multiband operations to support wireless devices such as Radio Frequency Identification Data (RFID) applications, Global System for Mobile Communications (GSM), Industrial Scientific Medical (ISM), Wireless Local Area Network (WLAN), Wireless Fidelity (WIFI, IEEE802.11b/g), and Worldwide Interoperability for Microwave Access (WIMAX).

Therefore, the development of compact planar antennas with a large or multi-frequency operation capacities, small size, low cost, and flexibility has become a real challenge research and has derived rapidly increasing attention in modern multi-standard wireless communication systems.

A number of multiband antennas has been proposed and many techniques have been used such as etching slots on the patch [1], H-shaped slot [2] or parasitic strip [3], defected ground plane [4] and truncated ground plane with use of an L-shaped notch in lower corner [5], inverted T-shaped notch in the middle, integration artificial magnetic conductor [6], implementing fractal structure [7], constructing electromagnetic bandgap structures [8], adding parasitic elements [9], feeding through coplanar waveguide [10], using defected/reformed of the ground plane [11].

In the present paper, a new monopole coplanar waveguide (CPW)-fed multiband antenna with a simple structure for tri-band of operation for multiple wireless communications is proposed. The antenna parameters are simulated and optimized by using Computer Simulation Technology

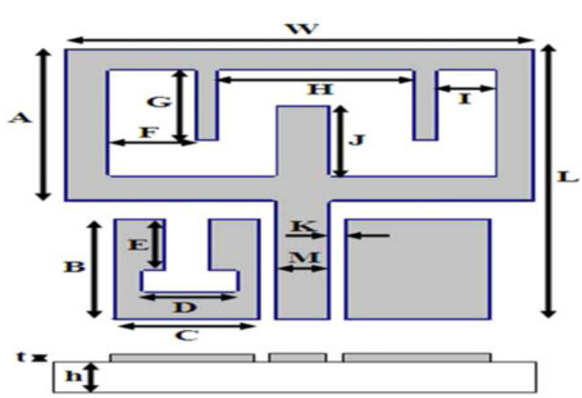

Fig. 1. Geometry of the final proposed multiband antenna.

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Table 1. The optimized dimensions of the proposed antenna.

Parameter	*A*	*B*	*C*	*D*	*E*	*F*
Value	12	11	7	5	4.5	2
Parameter	G	H	I	J	K	M
Value	7.5	10	2	7.5	0.4	3.2

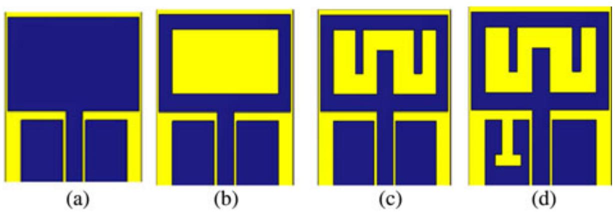

Fig. 2. Design evolution of the proposed multiband antenna.

Microwave Studio (CST MWS) and the design considerations of the proposed multiband antenna are discussed and described.

II. ANTENNA DESIGN AND PERFORMANCES

The details of the geometrical configuration parameters of the final proposed multiband planar microstrip antenna are presented in Fig. 1. This antenna is implemented on a low-cost FR4 epoxy substrate with a relative permittivity ϵ_r of 4.4, a thickness of $h = 1.6$ mm and a loss tangent tan of 0.025 and is fed by a CPW-fed transmission line with 50 Ω characteristic impedance. The radiator patch antenna and the feeding are implemented on the same plane of the substrate with a single side metallization. The dimensions of the designed

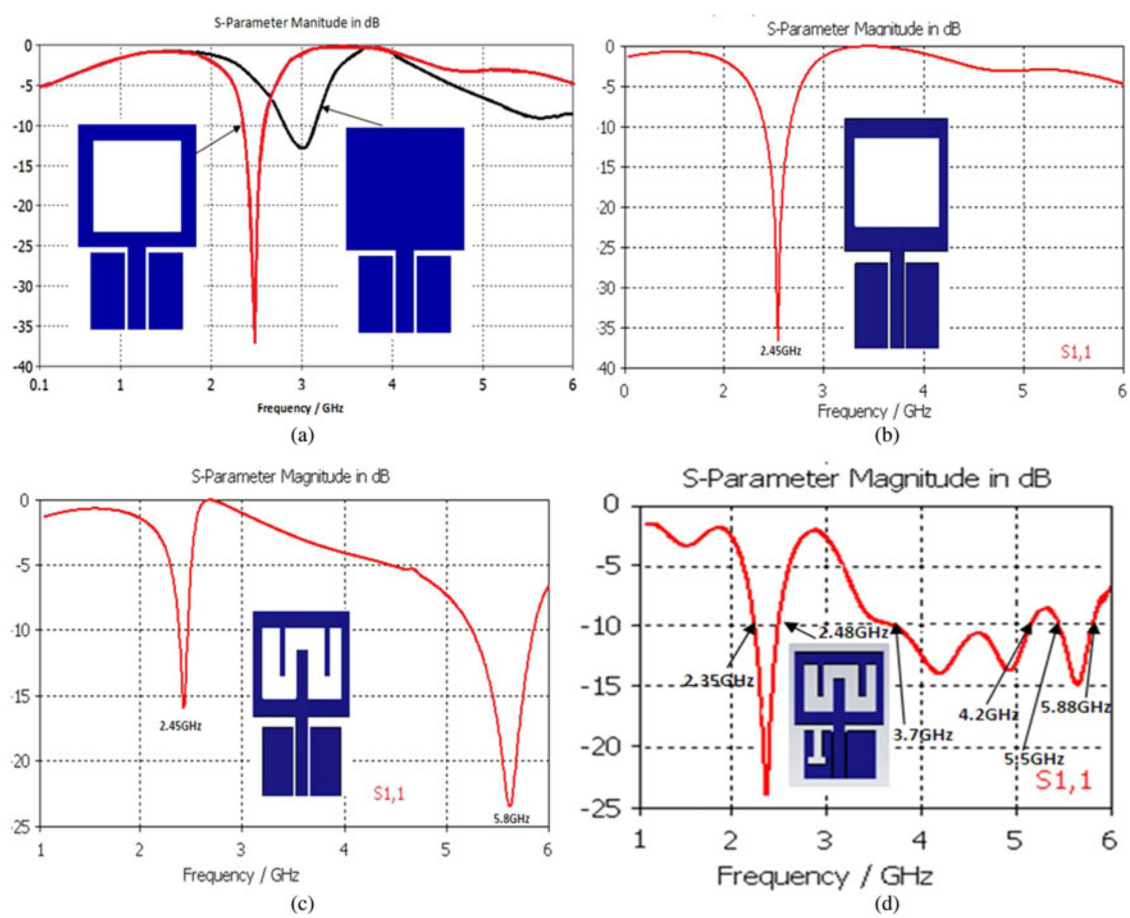

Fig. 3. Return loss versus frequency of the proposed monopole antenna for various steps of the optimizations.

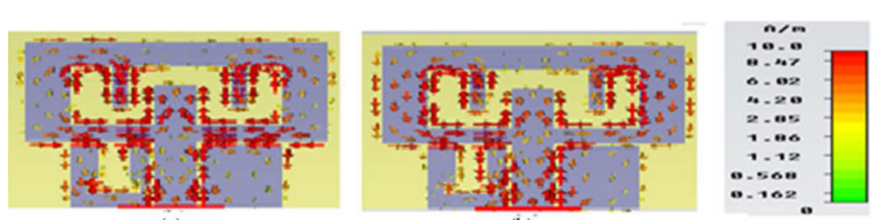

Fig. 4. Surface current distributions of the final monopole multiband antenna at (a) 2.4 GHz and (b) 5.8 GHz

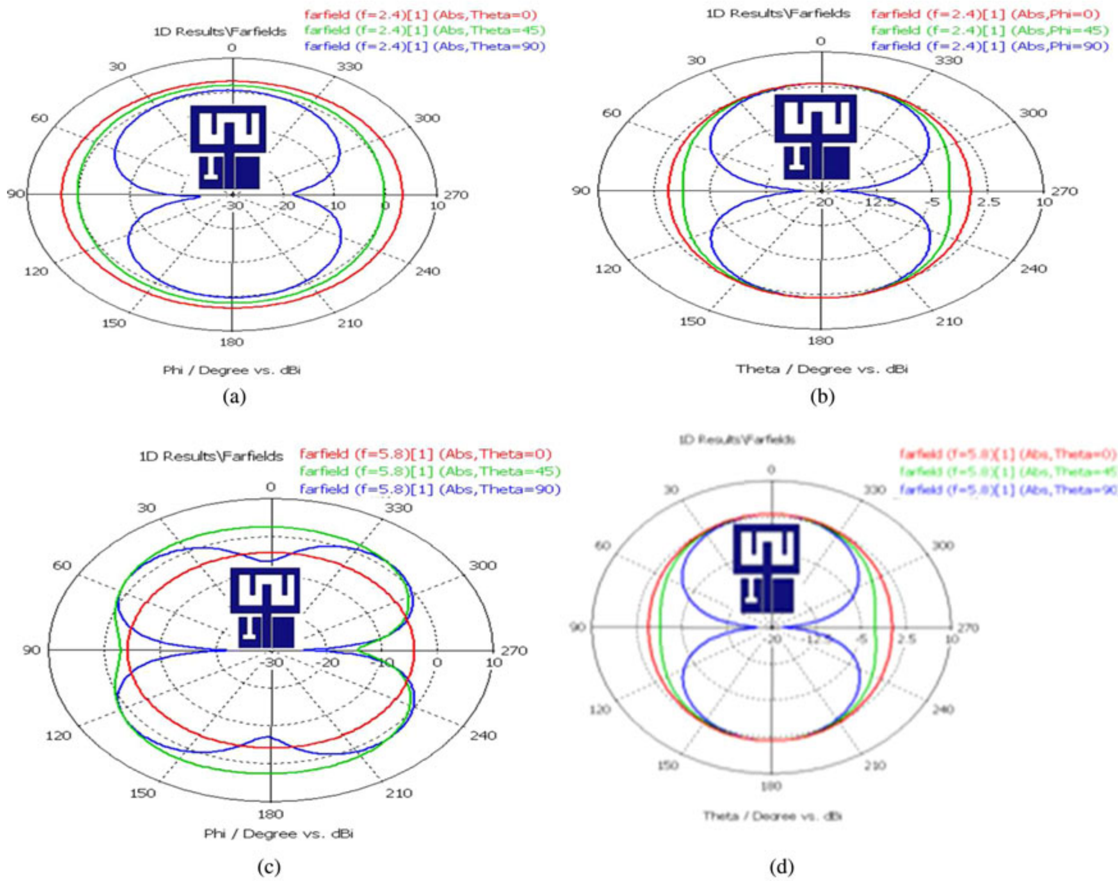

Fig. 5. Radiation pattern at 2.4 and 5.8 GHz of the final proposed multiband antenna.

Fig. 6. Anechoic chamber.

Fig. 7. Photograph of the achieved multiband antenna.

compact antenna are 25 × 25 mm². Several aspects were considered to optimize the final antenna design. All the design and simulated results are performed by using CST MWS and ADS "Advanced Design System". After the optimizations of the parametric antenna geometry, the parameters of the final structure antenna are listed in Table 1.

The goal of this study is to develop a new compact antenna structure for multi-frequency band to multiple incorporating operation service. The design evolution of the proposed antenna is presented in Fig. 2. The simulated return loss for the proposed antenna with different optimized dimensions of the parametric study is shown in Fig. 3. Firstly, the mono-band antenna is constructed by a rectangular slot with optimized dimensions from a radiator patch shown in Fig. 3(a)

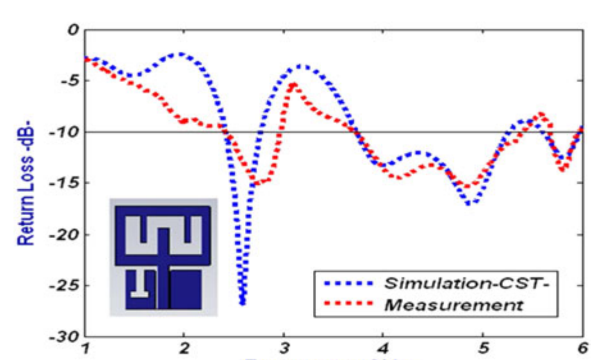

Fig. 8. Simulated and measured return loss versus frequency.

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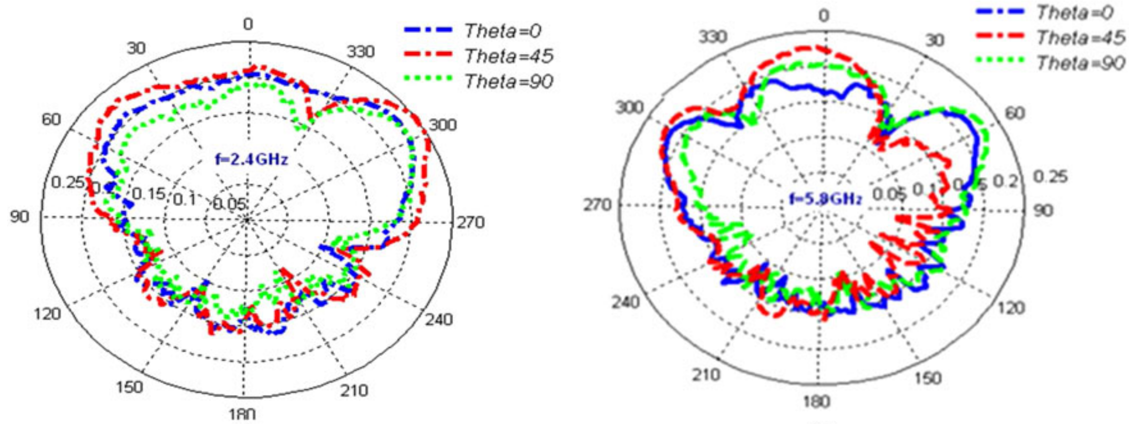

(a) (b)

Fig. 9. Measured radiation pattern at 2.4 and 5.8 GHz.

to be adapted to frequency center 2.4 GHz with a bandwidth the 130 MHz. Secondly by adding a three parallel stubs after several optimizations of the dimensions and the and the position en the level of the slot rectangular radiator patch, the dual-band antenna is obtained and is operates in these frequency bands: (2.35–2.48 GHz) and (5.3–5.8 GHz) as shown in Fig. 3(c) with a better band at 5.8 GHz due of the gap between of the stub tuning and the current distribution flow mode in radiator patch.

At last, the final tri-band antenna is achieved by a T-shaped slot inverted on the ground plane as shown in Fig. 3(d). Thus, we achieved the final proposed antenna ranging at multiple frequency bands: (2.35–2.48 GHz), (3.7–5.2 GHz), and (5.7–6 GHz) with a return less than −10 dB.

The current distribution of the final proposed antenna for three frequencies is shown in Fig. 4. It is observed that the surface currents distributions are concentrated around the slot of the radiator patch and CPW transmission line.

Figure 5 shows the simulated 2D far-field radiation patterns of the antennas on *E*-plane and *H*-plane at 2.4 and 5.8 GHz. The simulated results show that the omnidirectionnel patterns in *E*-plane and bidirectionnel in *H*-plane for all frequency bands.

III. ACHIEVEMENT AND MEASUREMENT

After the study, conception and optimization of the compact tri-band antenna by using CST, the prototype of the investigated antenna was achieved and measured to verify the performance of the results obtained from simulation. The return loss was measured by using Vectorial Network Analyzer (VNA) R&S@ZVB20 from Rohde& Schwarz, and the radiation patterns were measured in Anechoic chamber as shown in Fig. 6. The photograph of the fabricated multiband antenna is given in Fig. 7.

The simulated and measured return loss against frequency of final tri-band proposed antenna are given in Fig. 8. It is clearly observed that the simulation results are in agreement with measurement. This allows the validation of a new compact and miniaturized uniplanar multiband antenna structure operating from 2.4 to 2.9 GHz, 3.7 to 5.2 GHz, and 5.7 to 6 GHz, with a return loss less than −10 dB.

The measured radiation patterns at 2.4 and 5.8 GHz as shown in Fig. 9.

IV. CONCLUSION

In this study, we have validated a new low-cost multiband antenna structure, suitable to operate in large frequency bands. All the conception, optimization, and simulation results are performed by using high electromagnetic simulator CST MWS. The strip lines and a slot techniques used in this work on the level of the radiator patch and the ground plane is a simple way to optimize and control the frequency band and to be adapted to the specific applications. The measured and simulation results are in agreement which validate the new compact antenna structure ranging from 2.4 to 2.9 GHz, 3.7 to 5.2 GHz, and 5.7 to 6 GHz operating in specific applications of ISM band, WLAN, WIMAX, and RFID.

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