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A Compact Monopole Antenna for Wireless Personal Area Network

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Abstract: A compact planar monopole antenna suitable for wireless personal area network (WPAN) application is proposed. By simply modifying the periphery of a rectangular patch, effective operational band 2.95 to 16.8 GHz is achieved. This band sufficiently covers the operating band, 3.1–10.6 GHz, of the new wireless personal area network (WPAN) using ultra wide band (UWB) technique. A prototype of the proposed antenna is fabricated and measured to verify the simulated performances of the proposed antenna. The antenna provides fractional bandwidth of 138%, peak antenna gain of 2.4 dBi. The proposed antenna is compact and of small size (20 X 30 X 1.6 mm^3) with a 50Ω feed line and offers a very simple geometry, suitable for low cost fabrication using printed circuit board technology.

Keywords: Monopole antenna, wireless personal area network, ultra-wideband, rectangular patch.

I. INTRODUCTION

Recently, interest in ultra-wideband (UWB) communication systems such as the new wireless personal area network (WPAN) covering band from 3.1 to 10.6 GHz has rapidly increased due to their many advantages including the low-spectral-density radiated power and potential for accommodating higher data rate. It is a well-known fact that planar monopole antennas present really appealing physical features, such as, simple structure, small size, and low cost. Due to all these interesting characteristics, planar monopoles are extremely attractive to be used in emerging UWB applications, and growing research activity is being focused to them. In the design of a UWB planar monopole antenna, the shape of the antenna patch, the ground plane, and the geometry of the ground plane slots are of great importance. Different methods [1-2] such as the truncated slot on the antenna patch or on the ground plane have been proposed for increasing the frequency range accepted by UWB applications. During the past years, related UWB antennas for WPAN have been proposed [3-4]. Throughout the literature, various methods to achieve wideband along with the band-notched characteristics are proposed. The conventional methods include, cutting a slot on the patch [5], using conductor-backed plane [6].

This article presents a planar monopole antenna for WPAN application with a compact dimension of 20 X 30 X 1.6 mm3. The design employs modification of the periphery of a rectangular patch. By optimizing the different parameters of the proposed antenna, a wider impedance bandwidth of 138% is achieved. Details of the proposed antenna structure and parametric studies are described in Section 2, and the measured results are discussed in Section 3.

II. ANTENNA GEOMETRY

Fig. 1 shows the geometry of the proposed antenna. The rectangular patch and ground plane are printed on the opposite side of an inexpensive dielectric substrate FR 4 glass epoxy of ε_r = 4.4 and dimension of 20 X 30 X 1.6 mm^3. The antenna is fed by a microstrip line of width 2 mm and length 16.3 mm, which provides better impedance matching. The periphery of the rectangular patch has been modified by a V-shaped void on the upper side and by two box shaped patch on two sides. Dimensions of different parameters of the proposed antenna are optimized after a good number of simulations for better impedance matching. The optimized parameters are given in the Table 1. A photograph of the prototype is shown in Fig. 2.

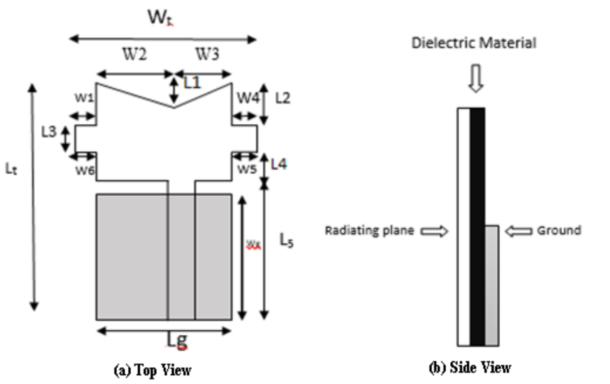

Fig. 1 Geometry of the proposed antenna.

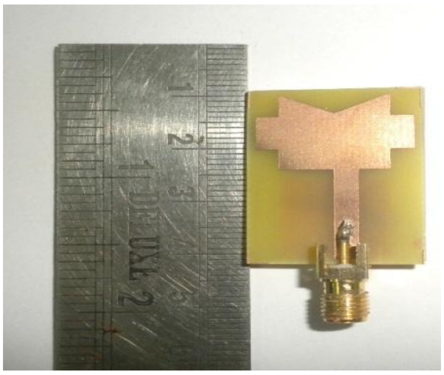

Fig. 2 Photographs of the prototype.

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TABLE I DIMENSIONS OF THE PROPOSED ANTENNA
(All dimensions are in mm)

W_t	20	L_t	30
W_1	3	L_1	1.3
W_2	7	L_2	3.4
W_3	7	L_3	4
W_4	3	L_4	5
W_5	3	L_5	16.3
W_6	3	Lg	14
Wg	15		

III. RESULTS AND DISCUSSIONS

Some sensitive parameters have been studied numerically to investigate the influence of the parameters on antenna performance. The frequency response of the antenna strongly depends on the geometry of the radiating patch and the ground plane. So, to optimize the antenna performances, an extensive parametric analysis has been performed with respect to the presence of V-shaped void and the box shaped patch, and gap variation between the radiating element and ground plane. In the simulation, only one parameter has been varied, whereas, the others have been kept constant. The simulations have been performed using MoM-based software ANSOFT designer V 2.2.

To study the effects of periphery modification of the patch on the impedance bandwidth, three different models have been considered. This is summarized in Fig. 3. This figure shows that for model-1 and model-2 impedance matching is not good, whereas the proposed configuration provides a large bandwidth of 13.85 GHz (2.95–16.8 GHz).

The gap between the radiating patch and ground plane plays an important role for impedance matching. When the gap is increased 2 mm impedance matching is not good. Impedance matching is better with gap = 1.3 mm. Change in S_{11} due to gap variation is presented in Fig. 4.

The implemented dimensions of geometry parameters of UWB monopole antenna is chosen, to achieve the optimum performance as predicted from parametric studies. Fig. 5 shows the measured and simulated frequency response of the reflection coefficient (S_{11}) for the proposed antenna.

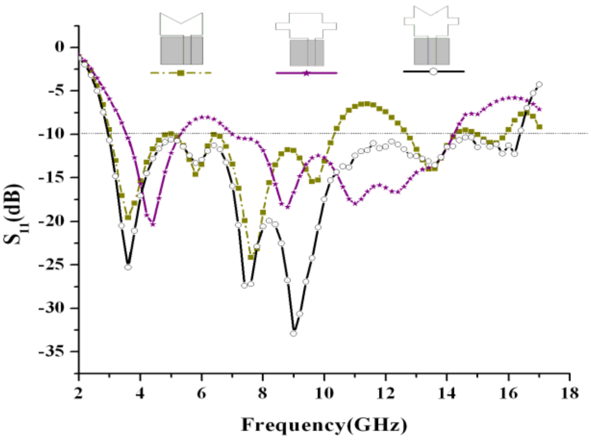

Fig. 3 Effects of periphery variation on the reflection coefficient S_{11}.

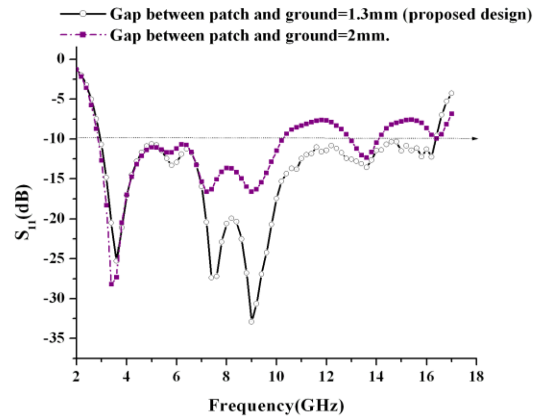

Fig. 4 Effects of gap variation on S_{11}.

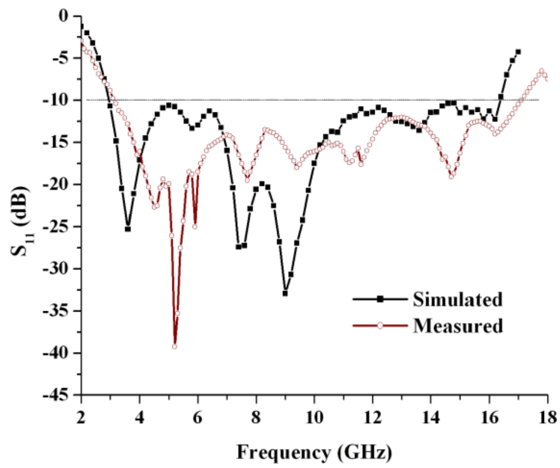

Fig. 5 Simulated and measured S_{11} for the proposed antenna.

The S_{11} is measured using a vector network analyzer. The measured impedance bandwidth, defined by $S_{11} \leq -10$ dB, is about 13.4 GHz (138%) starting from 2.98 GHz to 16.38 GHz. Comparison between simulated results and the measured results show reasonable agreement throughout the band. However, the measured results display slightly difference at operating frequencies. The disagreement between simulation and measurement may be due to the fabrication tolerance.

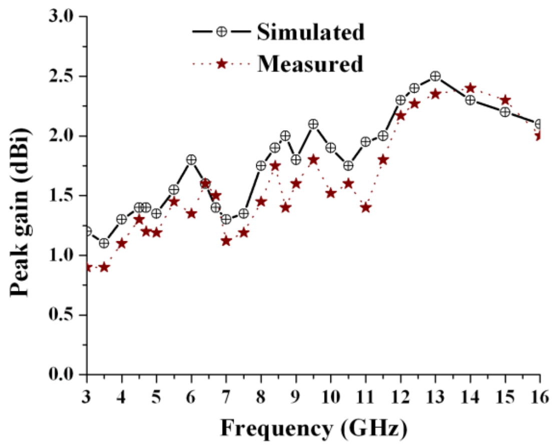

Fig.6. Comparison between the measured and simulated peak gain of the proposed antenna.

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The simulated and measured peak gain of the proposed antenna is shown in Fig. 6. It reveals that the antenna gain ranges from 0.8 dBi to 2.4 dBi within 3 GHz to 16 GHz frequency band. The maximum realized gain is 2.5 dBi at 13 GHz (simulated) and 2.4 dBi at 14 GHz (measured). Nature of simulated and measured plot of peak gain vs. frequency is almost in parity.

IV. CONCLUSION

A novel microstrip-fed planar patch antenna designed by simply modifying the periphery of the patch for UWB operation has been presented. The proposed antenna is very simple in structure and with compact size provides ultra wide band to cater for the WPAN standard. Also, the prototype has been constructed and measured to show a good agreement with the simulated results.

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