A Compact Monopole Antenna With Filtering Response for WLAN Applications

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***Abstract*—A novel compact monopole antenna with filtering response for WLAN applications is presented in this paper. The antenna is composed of a capacity-loaded matching patch, two resonators, and two end-coupled monopoles. The resonators consist of wide rectangular patches and narrow shorted lines to form the resonance, and the resonators are printed on the different layers to increase the design flexibility. Two meandering monopoles are located at the edges of the top layer with capacitive coupling at each other's end. The mutual couplings between the meander monopoles are utilized to produce two radiation nulls at the two band-edges. Based on the design method, the prototype of the proposed antenna was designed, fabricated and measured. The measured results show that the antenna has a broad bandwidth of 16% for S_{11}<-10 dB. Also, ideal omnidirectional radiation patterns, and steep band-edge selectivity with two radiation nulls are achieved for the proposed antenna.**

***Index Terms*—Compact antenna, filtering response, monopole antenna, WLAN applications.**

I. Introduction

As the fast development of the modern wireless communication technologies, there are increasingly strict requirements on the performances of antennas. Recent years, antennas with filtering characteristic are much welcomed by many researchers because of their high integration, compact size and good filtering radiation performance [1]. Another appealing benefit for filtering antennas is that when the filtering characteristic is integrated into the antenna, the designer will take the overall consideration for the antenna and the filter, and the mismatch between them will be largely reduced [2].

Attracted by their attractive features, filtering antennas have been investigated and reported by many researchers. The Γ-shaped monopole antenna [3] was designed with three-pole filtering property for omnidirectional communication systems. However the band-edge selectivity was not very good due to its simple configuration. Patch antennas can also perform filtering properties and have unidirectional radiation patterns [4]-[7]. By using the elaborately designed feeding lines, [6] and [7] presented a dual-polarized filtering antenna and a differential filtering antenna with good radiation performances. However, in these designs, multi-layer techniques were applied with the increased fabrication costs. Filtering microstrip antenna arrays [8]-[9] were designed with filtering power dividers and baluns for high gain and reduced side-lobe. The design procedure was complicated for the design of the coupled microstrip lines. In [11] and [12], high frequency selectivity was obtained because of two transmission zeros realized for a balanced dipole antenna [11] and a slot-line antenna [12], but radiation patterns are not ideal enough for the omnidirectional radiation application.

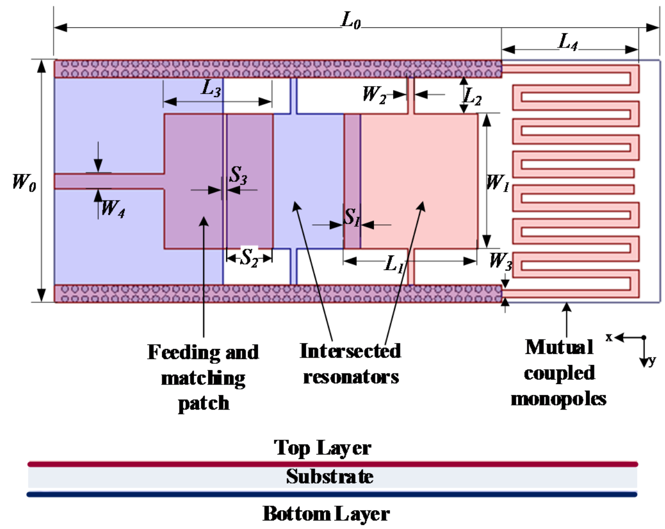


Fig.1. Detailed configuration of proposed antenna.

TABLE I

Detailed design parameters in Fig. 1

Parameter	W_0	W_1	W_2	W_3	W_4	S_1	S_2
Value (mm)	14.4	8	0.4	0.5	0.9	1	2.8
Parameter	L_0	L_1	L_2	L_3	L_4	S_3	
Value (mm)	36	8	2.2	6.5	7.5	0.2	

In this paper, a novel compact monopole antenna with filtering response for WLAN applications is presented. The antenna is comprised of the capacity-coupled patches for impedance matching, two quasi-CPW resonators, and two mutual end-coupled monopoles. By using cascading resonators and end-coupled monopoles, two radiation nulls are realized at two band-edges for the presented antenna. For verification, a prototype of the proposed antenna was fabricated and measured. Both the simulated and measured results show that the antenna has a high band-edge selectivity and ideal omnidirectional radiation patterns, which can be a good candidate for WLAN applications.

II. Antenna Design

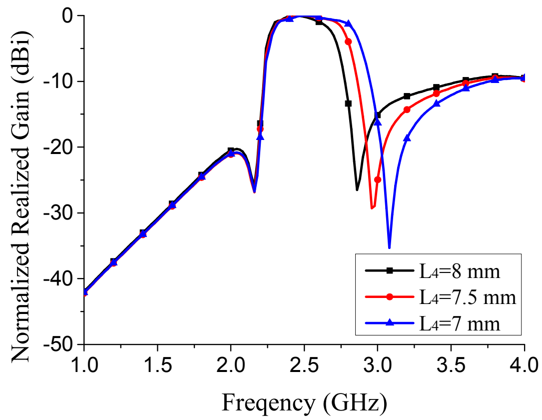


Fig. 2. Frequency variation of radiation nulls as the design parameters L_4.

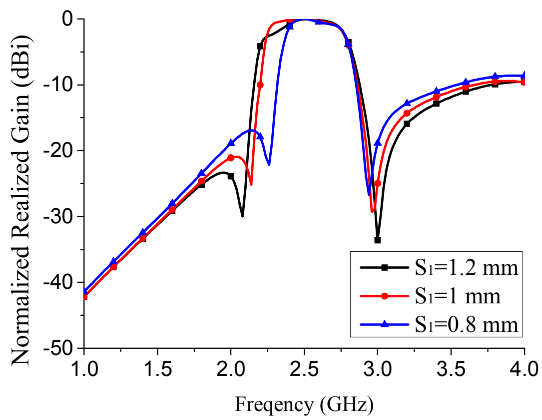


Fig. 3. Frequency variation of radiation nulls as the design parameters S_1.

A. Configuration

The detailed configuration and design parameters of the proposed monopole antenna are shown in Fig. 1. There are three different parts of the antenna, a capacity-loaded patch functioning as the feeding and matching element, two partly overlapped resonators and two radiated monopoles. A low cost FR4 substrate with relative permittivity of 4.4 and thickness of 0.5 mm is used in this design. Detailed lengths of the antenna structure parameters are shown in the Table I.

The feeding and matching patch, which can be equivalent of the parallel and series matching capacities, is connected to a 50Ω microstrip feeding line. The resonators are intersected with each other on different layers to form a capacitor, and they are shorted by narrow microstrip lines to the edges of the substrate with plated via holes, which is equivalent to the parallel inductors. At the end of the antenna, two monopoles are allocated on the both edges of the top layer. To keep the compact size, monopoles are bent into the meander lines. Because of the close interaction between the radiation elements and the two monopoles, good filtering character is realized with two gain zeros on both side edges of the antenna operation frequency band.

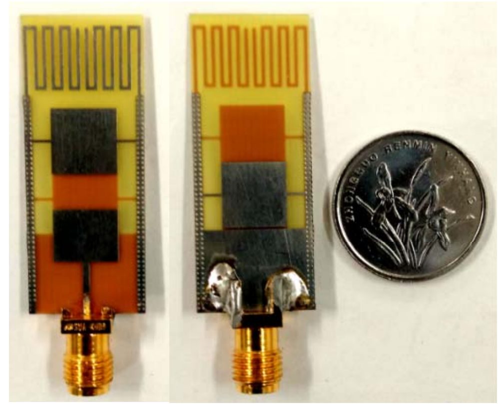


Fig. 4. Photographs of the proposed antenna.

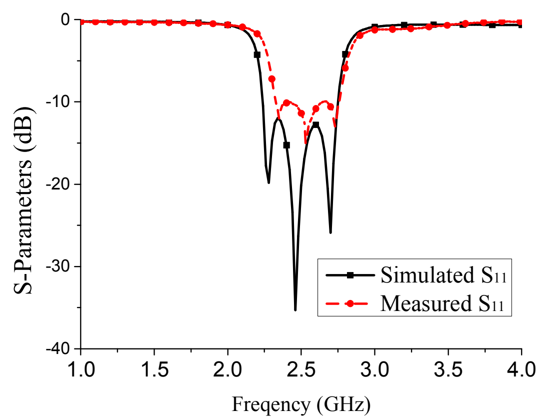


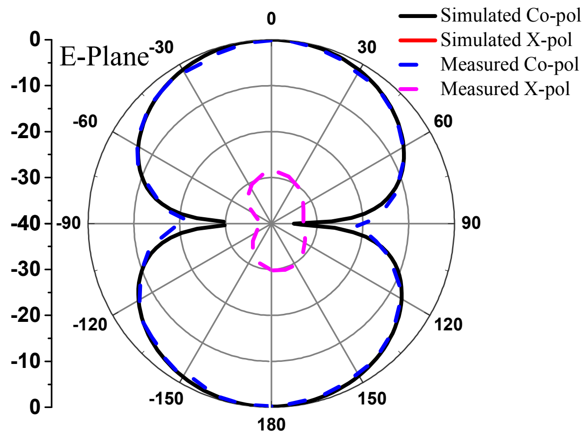
Fig. 5. Measured and simulated S-parameters of the proposed antenna.

B. Antenna Study

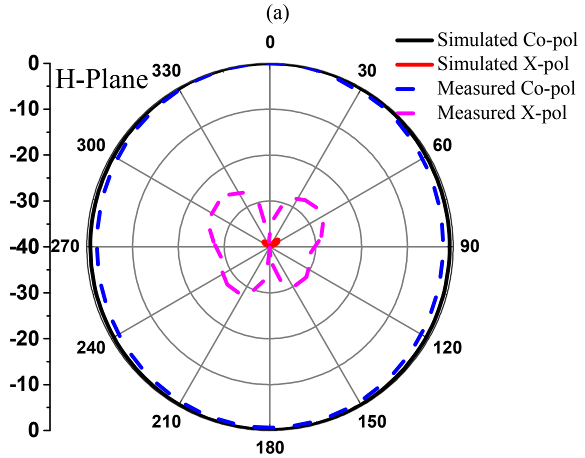
In order to study the two radiation nulls, parametric study is performed in this section. Detailed study reveals that the parameters L_4 and S_1 have more sensitive effect on the antenna two radiation nulls. As is shown in Fig. 2, when the parameter L_4 is decreased from 8 mm to 7 mm, the realized peak gain null at the higher band edge shifts to the higher frequency, while the realized peak gain null at the lower band edge remains unchanged. In addition, as shown in Fig. 3, by tuning the length S_1, the gain null at the lower band edge shifts much severely compared to the higher band edge. Similarly, when the length S_1 is decreased, the realized peak gain null at lower band edge moves to the higher frequency.

III. RESULTS AND DISSCUSSION

The proposed antenna was designed and fabricated on an FR4 substrate for low cost realization, and the photograph of the fabricated prototype is shown in the Fig. 4. The prototype was measured by a ROHDE & SCHWARZ network analyzer and a far field antenna measurement system. Both the measured S_{11} and the simulated S_{11} are shown in the Fig. 5 for comparison. Because of the unstability of the FR4 substrate and some fabricated errors, compared to the simulated results, the measured S_{11} is slightly deteriorated and the frequency



(a)



(b)

Fig. 6. Measured and simulated radiation patterns of the antenna. (a) E-plane. (b) H-planes.

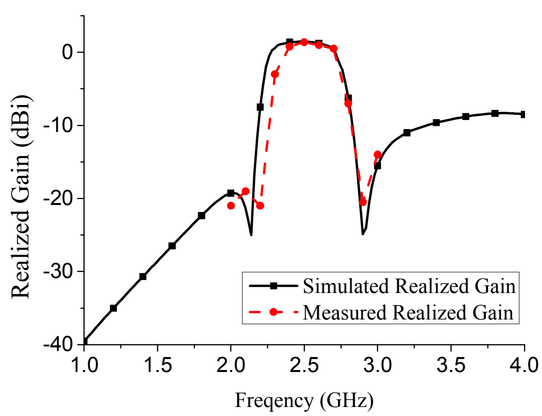


Fig. 7. Realized gain of the proposed antenna.

bandwidth is also narrowed. However, the measurement results clearly show that there are three resonating frequencies, and the measured impedance bandwidth for S_{11}<-10dB are 420 MHz form 2.33 GHz to 2.75 GHz.

Fig. 6 shows the normalized measured and simulated radiation patterns at the frequency of 2.5 GHz. The proposed monopole antenna radiates as a typical monopole antenna. Its E-plane (xz plane) is a doughnut-shaped pattern, and H-plane is an omnidirectional pattern. Both of them have a very low cross-polarization level in the $\pm z$ direction, which are lower than -20 dB. The measured realized gain in the frequency band is about 1.3 dBi as is shown in the Fig. 7. It is also verified that the antenna have two gain zeroes at two band edges, and the depth of the nulls is lower than -20 dB. With the ideal omnidirectional radiation characteristic and two gain zeroes at the band edges, it is a good candidate for WLAN wireless communication systems.

IV. Conculsion

This paper presents a novel compact monopole antenna with filtering response for WLAN applications. Based on the configuration of the quasi-CPW structure, resonators and monopoles, a good filtering antenna is designed and fabricated for verification. Simulated and measured results show that the antenna has a wide impedance bandwidth of 16% for S11<-10 dB, a good band edge selectivity with two controllable realized gain nulls, and an ideal omnidirectional radiation pattern.

Acknowledgment

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