

# A Study on Miniaturized Microstrip Antenna for IoTs Sensor Applications

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**Abstract.** A 2.4 GHz microstrip antenna with compact structure for IoTs applications is presented. A parallel resonant capacitor is introduced to miniaturize the size of 2.4 GHz antenna, and to expand the frequency bandwidth, a quasi-dipole is designed on the opposite layer of the L-shaped microstrip antenna. Moreover, the antenna gain is also increased by using this method. In order to examine the feasibility of the proposed structure, a new type of 2.4 GHz microstrip antenna is designed, fabricated, and measured. The experimental results of the fabricated circuit show broad bandwidth of 122MHz and a relative high antenna gain of 2.42 dBi.

## Introduction

With the rapid development of IoTs, more and more attention has been paid to the technology of short distance wireless communication antennas, especially 2.4 GHz antenna. Generally, the mobile communication equipment usually requires small antenna size, wide bandwidth, easy to integrate and conformal with the device. Microstrip antenna, with its small size, low profile, easy integration and low cost, become more preferred in the wireless communication band. However, in many practical applications, the microstrip antenna also exposes some disadvantages, such as narrow band, low gain and so on. In recent years, the technology of broadband, high gain and miniaturization has been the research focus of microstrip antenna<sup>[1]-[3]</sup>. A. Adrian and D.H. Schaubert proposed a method to obtain good bandwidth characteristics by adding an additional parasitic radiation element<sup>[4]</sup>, however, the antenna size is a little large. Moreover, a great progress has been made in the the researches of [5]-[6], which are based on low thickness of the dielectric substrate, slot coupled feed, additional impedance matching or stacked structure. In addition, some microstrip antenna has been introduced in the literature [7]-[9] respectively, by using the patch meander, grounding meander and short-pin inserting technology, the size of the antenna can be decreased by about half at the operating frequency of the antenna. However, this kind of antenna has narrow bandwidth and low gain.

Based on the above, the design of a compact, broadband and high gain microstrip antenna has become an urgent research topic.

In this paper, a new method is proposed, and a compact microstrip antenna with broad bandwidth and high gain is designed.

## Antenna Design

The proposed 2.4 GHz microstrip antenna consists of two layers, including the radiation patch on the top layer with 13 x 4 mm<sup>2</sup> based on FR4 printed board and the grounding on the bottom layer with 30 x 25 mm<sup>2</sup> printed board. The radiation patch is actually an improvement on a conventional rectangular patch antenna, which is a slot inserted in the center of the rectangular patch. Moreover, the rectangular with the slot is divided into two parts, one placed on the upper layer and another put on the bottom layer, as shown in Fig 1. The fed point is indicated as Fig. 2.

The proposed design method in this paper is to modify the structure on the basis of the *l* antenna<sup>[11]</sup>. As shown in Fig. 1, the slot spacing  $d_l=0.7\text{mm}$ , it is very small, the capacitance effects far outweigh the effect of inductance from the perspective of equivalent circuit. Therefore, the proposed antenna is equivalent to the L-shaped antenna connected in parallel with a resonant capacitor. Through the parallel resonant capacitance method can not only easily adjust the resonant frequency (as shown in Fig.3), can also further reduce the antenna size.

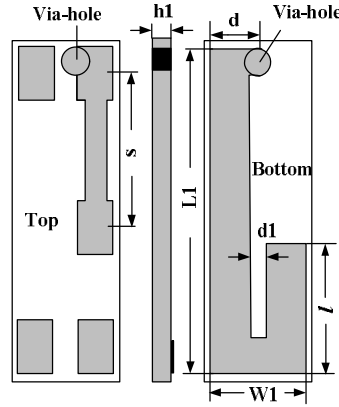


Fig. 1 Vertical view of antenna.

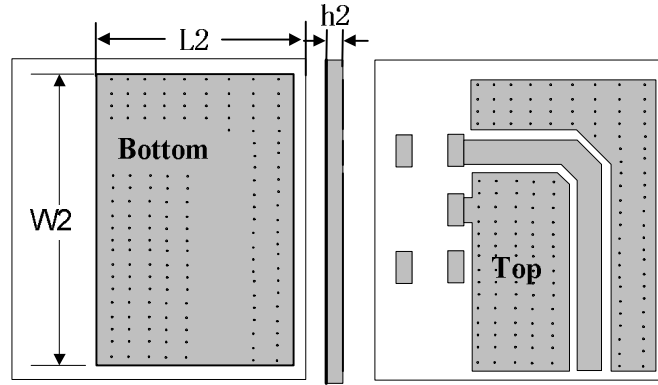


Fig. 2 Vertical view of test board.

The capacitance value of the parallel resonant capacitor can be easily adjusted by the length  $l$  and the gap width  $d_l$ . When the gap width  $d_l$  is reduced or the length  $l$  increases, the parallel capacitance becomes greater. Thus the antenna size is reduced, as well as the resonant frequency becomes lower, as shown in Fig. 3. However, with the reduction of the antenna size, the frequency bandwidth and antenna gain will decrease, which affect the performance of the antenna.

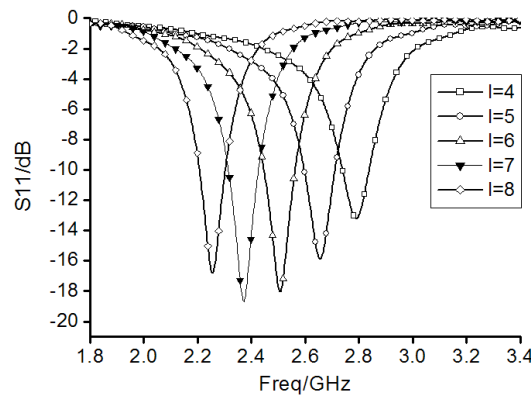


Fig. 3 Return losses with different  $l$ .

In order to overcome the defects, this paper proposed a new design method by modifying the grounding and radiation patch structure.

Firstly, a quasi-dipole is structured by using the radiation patch on the upper layer and the grounding structure on the bottom layer. By using this structure, the radiation efficiency of the antenna can be enhanced, and the gain of the antenna can be improved. Moreover, by increasing the thickness of the circuit substrate, the bandwidth of the antenna can be expanded. In addition, the method also has the

effect of inhibiting the higher mode and enhancing the radiation of the base mode, thereby further improving the gain.

The input impedance matching can be accomplished by adjusting the via-hole to the edge of the radiation patch distance  $d$  and stub length  $s$  easily.

## Simulation and Measurement Results

Through simulation and optimization, the structure parameters are shown in Table 1.

Table 1 Structure parameters.

Items	Size	Units	Items	Size	Units
$h_1$	1.1	mm	$h_2$	1	mm
$L_1$	12	mm	$L_2$	30	mm
$W_1$	3.3	mm	$W_2$	25	mm
$d_1$	0.7	mm	$d$	1.8	mm
$l$	6.5	mm	$s$	5.7	mm

Where dielectric constant  $\epsilon_r = 4.4$ , loss tangent  $\tan \delta = 0.001$ .

The fabricated antenna is shown in Fig. 4, and the return loss  $S_{11}$  parameters of the antenna are measured by using the Agilent network analyzer E7501. As shown in Fig. 5, the measurement and simulation results agree well and illustrate that the antenna bandwidth ( $S_{11} < -10\text{dB}$ ) is from 2.396 ~ 2.518 GHz, relative bandwidth reaches about 4.98%, which can prove the effectiveness of the proposed antenna design method.

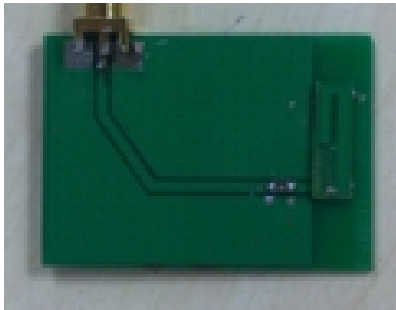


Fig. 4 Fabricated antenna.

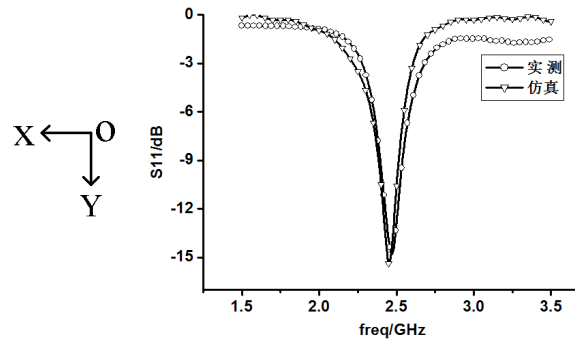


Fig. 5 Return loss.

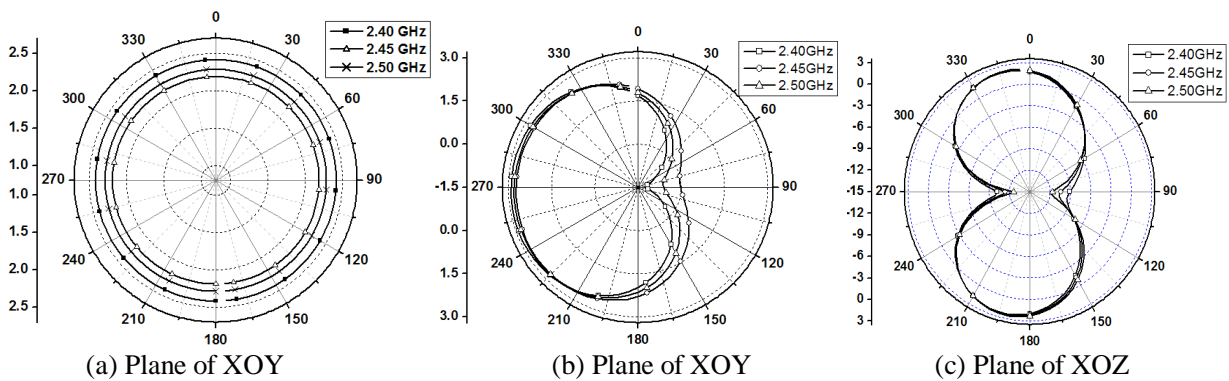


Fig.6 Radiation pattern.

The antenna gain of simulation results are as shown in Fig. 6. The radiation pattern can meet the requirements and the maximum gain of 2.42dBi is quite satisfactory.

## Conclusions

In this paper, a new 2.4 GHz microstrip antenna is proposed. It presents a miniaturization, broadband and high gain characteristics. Through simulation and measurement, the antenna is about 4.46% of the conventional antenna size, with 122MHz bandwidth ( $S_{11} < -10\text{dB}$ ) and the maximum gain of 2.42dBi. The feasibility of this design approach is verified by theoretical simulation and physical measurement. Therefore, the proposed antenna can be used in IoTs sensor applications, such as ZigBee, WiFi and Bluetooth or any other applications working at 2.4 GHz.

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