Dual Band Microstrip Antenna with Rhombus Stub for WLAN Applications

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1. Introduction

Microstrip antennas are communication devices which designed for support wireless communication systems. Microstrip or printed antennas are low profile, small size, low cost and light weight [1]-[2]. However, microstrip antenna inherently has narrow bandwidth. Previously, the study of coplanar antenna (CPA) using slit and stub insertion in antenna has been designed for wireless communication systems with improved bandwidth and size reduction [3]-[4].

In this paper, the microstrip antenna with rhombus stub and using a pair of bent-slits loaded fed by microstrip line is presented. The prototype antenna has been developed from [4]-[6] which is dual band microstrip antenna using in WLAN communications coverage IEEE 802.11b/g (2.4-2.4835 GHz), IEEE 802.16a (5.15-5.35 GHz) and IEEE 802.16d (5.7-5.9 GHz). The size of this prototype antenna has been reduced about 40% of [4] and 15% of [5]. The dual band frequency of this prototype antenna was controlled by adjusting rhombus stub and bent-slit loaded. In simulation of the return loss, gain and radiation pattern was using software IE3D program.

2. Structure of Antenna

The structure of microstrip antenna with rhombus stub and using a pair of bent-slits loaded are consisting of 4 importance parts as shown in Figure 1. The first part of this microstrip antenna is patch antenna (design for width (W) and length (L)) which can be calculated by [2] and [7]. In this case, W is 42 mm and L is 33 mm. After tuned the antenna by adding rhombus stub, the dimension of microstrip antenna has been reduced to W=37 mm and L=15 mm.

The second part is the microstrip line which designed for matching impedance using the characteristic impedance of transmission line is 50 Ohms [1]. The calculation of microstrip line can be done by following:

$$\frac{W2}{h} = \frac{2}{\pi}\left\{B - 1 - \ln(2B - 1) + \frac{\varepsilon_r - 1}{2\varepsilon_r}\left[\ln(B - 1)\right] + 0.39 - \frac{0.61}{\varepsilon_r}\right\} \quad (1)$$

Where $W2$ is the width of microstrip line, h is the thickness of the dielectric substrate, $B = \frac{60\pi^2}{Z_0\sqrt{\varepsilon_r}}$ and Z_0 is characteristic impedance.

The third part is rhombus stub with designed for adjustment resonance frequency of microstrip antenna for WLAN communications coverage IEEE 802.11b/g (2.4-2.4835 GHz), IEEE 802.16a (5.15-5.35 GHz) and IEEE 802.16d (5.7-5.9 GHz).

The final part is a pair of bent-slits loaded as shown in left and right side of the microstrip antenna. The function of this part is increase bandwidth of lower and upper resonance frequency. The dimensions of a pair of bent-slits loaded have 4 parameters: L1, L2, W4 and W5 can be defined by using empirical method [5].

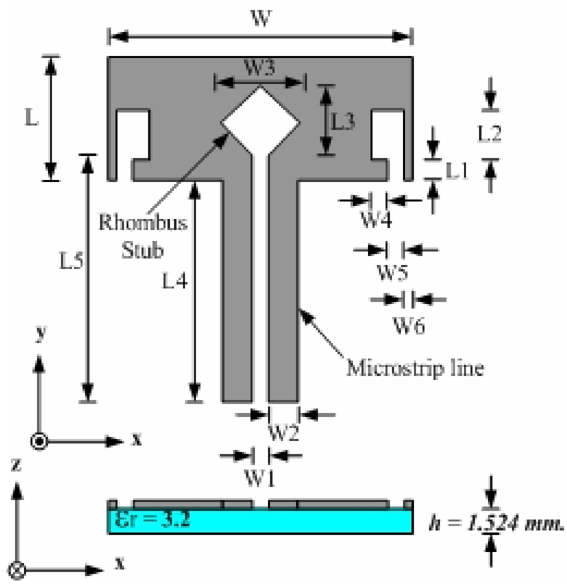


Figure 1: Structure of microstrip antenna with rhombus stub and a pair of bent-slits loaded

The microstrip antenna prototype was designed and fabricated on GML 1032 with 1.524 mm of thickness (h), and 3.2 of dielectric constant (ε_r). The dimension of microstrip antenna has the following parameters: W = 37 mm, W1 = 3 mm, W2 = 3.6 mm, W3 = 9.6 mm, W4 = 2 mm, W5 = 2 mm, W6 = 1 mm, L = 15 mm, L1 = 2.5 mm, L2 = 6 mm, L3 = 8.6 mm, L4 = 27 mm, L5 = 30 mm are shown in Figure 1.

3. Simulation and Results

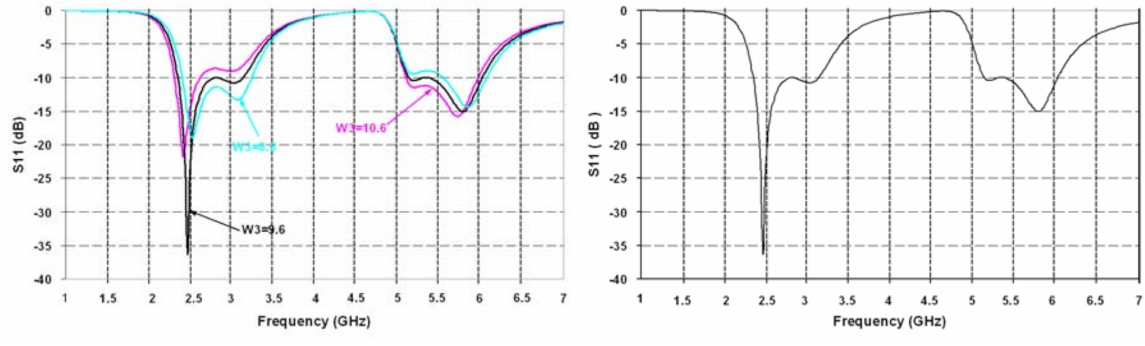
In this paper, the simulation was done by using IE3D program, which was adjusted all parameters for optimization results. The dimension of a pair of bent-slits loaded and rhombus stub are shown in Figure 1. The parameter W3 of the rhombus stub is used to control the lower and upper resonance frequencies. The simulation results of return loss (S11) when the dimension of W3 was changed as shown in Figure 2 (a).

In Figure 2 (a), the results had shown that when increase the length of rhombus stub (W3), the lower and upper resonance frequencies will be decrease. If decreasing the length of rhombus stub (W3), the lower and upper resonance frequencies have been increased as shown in Table 1. The optimization size of W3 is 9.6 mm, which has return loss (S11) of -36.41 dB and bandwidth of 0.787 GHz (2.351-3.138 GHz) at lower resonance frequency (2.465 GHz). At upper resonance frequency (5.793 GHz), the simulation results are S11 of -15.06 dB and bandwidth of 0.883 GHz (5.138-6.021 GHz) as shown in Figure 2 (b).

4. Fabrication and Measurements

The fabrication prototype antenna (using the same size as simulation results) has been done as shown in Figure 3. The antenna is fabrication on GML 1032 with thickness of 1.524 mm and dielectric constant of 3.2. The S11 and radiation pattern of prototype antenna have been setup and measured by using Agilent E8363B network analyzer and HP E4407B spectrum analyzer. The simulations and measurements of S11 are compared as shown in Figure 4. In Figure 4, the simulation of dual resonance frequency and bandwidth are agreed with the measurement results.

In Figure 5-6, the simulation and measurement of gain and radiation pattern at lower resonance frequency (2.465 GHz) and upper resonance frequency (5.793 GHz) are plotted in x-z plane and y-z plane. The directions of radiation pattern are radiated in bi-directional at 0 degree and 180 degree.



(a) (b)

Figure 2: Characteristics of return loss (S11) (a) varying of W3, (b) Fixed W3 = 9.6 mm

Table 1: The Results of Return Loss (S11) when very W3

W3 (mm)	Resonance Freq. (GHz)	Bandwidth (GHz)	S11 (dB)
10.6	2.417	0.301 (2.315-2.616)	-21.87
	5.727	0.865 (5.102-5.967)	-15.79
9.6	2.465	0.787 (2.351-3.138)	-36.41
	5.793	0.883 (5.138-6.021)	-15.06
8.6	2.526	0.835 (2.405-3.240)	-19.04
	5.853	0.565 (5.553-6.069)	-14.45

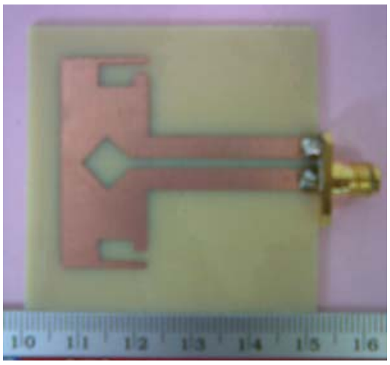


Figure 3: A photograph of microstrip antenna

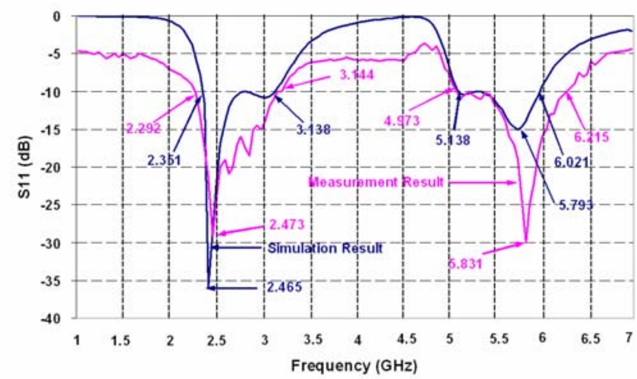
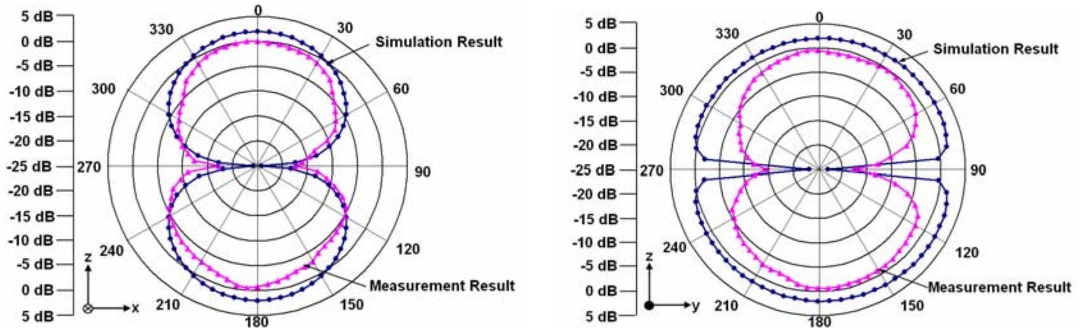
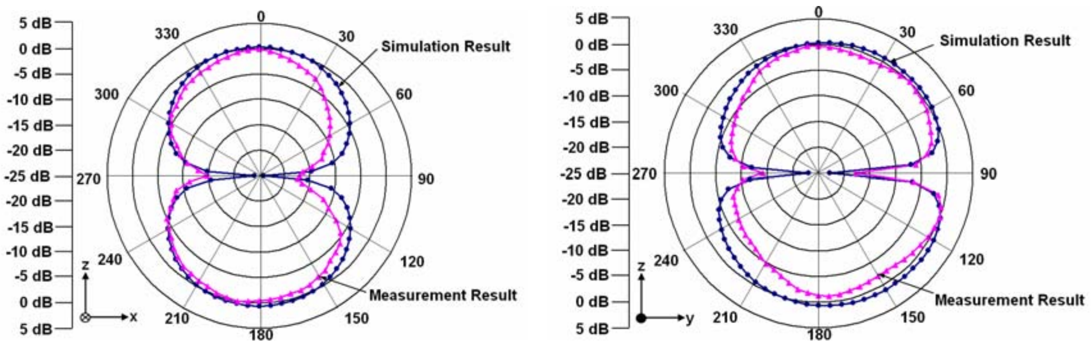


Figure 4: The comparison of the return loss simulation and measurement results



(a) (b)

Figure 5: Measurement and simulation results of radiation pattern at 2.465 GHz,
(a) x-z plane, (b) y-z plane



(a) (b)

Figure 6: Measurement and simulation results of radiation pattern at 5.793 GHz,
(a) x-z plane, (b) y-z plane

5. Conclusions

The microstrip antenna with rhombus stub and using a pair of bent-slits loaded was designed and fabricated which supports WLAN communications for dual band frequency. The lower bandwidth is 0.787 GHz (2.351-3.138 GHz) at resonance frequency: 2.465 GHz and upper bandwidth is 0.883 GHz (5.138-6.021 GHz) at resonance frequency: 5.793 GHz. The dimension of this microstrip antenna has been reduced to W=37 mm and L=15 mm. The optimization W3 of rhombus stub is 9.6 mm. If the parameter W3 is more than 9.6 mm, the lower and upper resonance frequencies will be decrease from 2.465 GHz and 5.793 GHz. The lower and upper resonance frequencies will be increase from 2.465 GHz and 5.793 GHz while the W3 is less than 9.6 mm.

References

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