2005 ASIA-PACIFIC CONFERENCE ON APPLIED ELECTROMAGNETICS PROCEEDINGS, December 20-21, 2005, Johor Bahru, Johor, MALAYSIA

Microstrip Dipole Antenna Analysis with Different Width and Length at 2.4 GHz

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Abstract – This paper discusses the design and simulation of microstrip dipole antenna at 2.4 GHz. In this antenna design, Agilent's Advanced Design System (ADS) software using momentum simulation is employed to analyze the entire structure. Different width (W = 3, 5, 7, 9 mm) of the arm of dipole antenna is analyzed to study on the performance of frequency resonance. From the simulation, the wider the width will lower the resonance frequency of the antenna. Different width makes the frequency resonance of the antenna shifting lower or higher than 2.4 GHz. In this case, the length (L) of the dipole arm is needed to be changed. Optimization value of the length is needed to make the frequency resonance at 2.4 GHz. The simulation result gives the bandwidth achieved of this microstrip dipole antenna is between 11 and 13 %. Three different width of dipole antenna have been fabricated and presented here in this paper. The properties of antenna such as input return loss and bandwidth have been investigated and compared between simulations.

1. Introduction

Microstrip antennas are frequently used in today's wireless communication systems because of their low profile, light weight and low production cost which widely have been researched and developed in the recent twenty years [1-4]. Nevertheless, there are several disadvantages of microstrip antennas. Narrow operation bandwidth is the main disadvantage. The bandwidth of the basic patch antenna is usually 1 – 3%. The bandwidth of the antenna depends on the patch shape, dielectric constant, the thickness of the substrate and the resonant frequency [5]. The design of microstrip antennas suitable for new WLAN to achieve dual-frequency or multi-band is developed in recent years.

Microstrip dipole is a narrow microstrip conductor on the true side of the substrate, which is interrupted by a feeding gap. Microstrip dipole or printed dipole antenna has been applied in communication devices such as notebook computer and access point for WLAN operations [6-7]. This type of microstrip dipole antenna usually has a narrow width and in this case it can be integrated at the access point of WLAN application

2. Microstrip Dipole Antenna Design

The approach proposed in this paper is to analyze and design microstrip dipole resonance at 2.4 GHz frequency band. Figure 1 shows the structure of a microstrip dipole of length ***L***, width ***W*** and gap ***G*** that were used in simulation. The proposed antenna element is printed on a FR4 substrate with a dielectric constant of 4.7, a thickness of 1.6 mm and a conductor loss of 0.019. The two hatched rectangular pieces in Figure 1 are copper on the top of the substrate. Each of it is connected with the microstrip bend. The gap between the two pieces is ***G*** and the microstrip dipole is fed at the middle of the gap. One piece of the hatched is fed with connector and another one is connected to the ground.

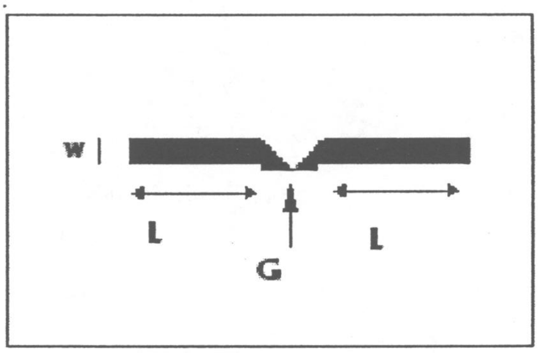

Figure 1: Microstrip Dipole Layout

Microstrip dipole of rectangular arm or rectangular geometry as shown in figure 1 can be designed for the lowest resonant frequency using transmission line model. The formula to calculate the value of λ and ***W*** can be found through formulation as follows [10]:

The effective dielectric constant (ε_{eff}) constant of a microstrip line is

$$\varepsilon_e = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left(\frac{1}{\sqrt{1 + 12d/W}}\right) \quad (1)$$

where ε_r = Dieletric Constant
d = substrate thickness
W= width of microstrip line (Different width is chosen here)

The length (***L***) of microstrip line using formula:

$$\lambda = \frac{c}{f\sqrt{\varepsilon_{eff}}} \quad (2)$$

where λ= wavelength
C= velocity of light
f = frequency

Thus $L = \lambda/4$

The length of each hatched rectangular is about quarter-wavelength. In this case the length of rectangular arm, $L = \lambda/4$=16.53 mm and the gap between the two pieces, ***G*** = 0.9 mm. Different width ***W*** is chosen here and in this case the value of width is chosen as 3mm, 5mm, 7mm and 9mm. This is done to analyze the frequency resonance of this type of antenna. Different length is then added to get the designated frequency at 2.4 GHz. The fabricated microstrip dipole prototype is shown in figure 2.

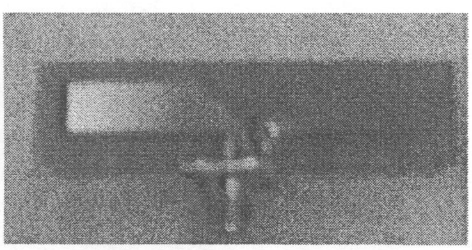

Figure 2: Fabricated Microstrip Dipole Antenna.

The taken to design microstrip dipole antenna are as follows:

- The resonance frequency has been chosen is 2.4GHz.
- The dipole dimension (L and W) is calculated by using microstrip transmission line formula.
- The rectangular hatched is been connected to microstrip bend and suitable gap G between the two hatched pieces on the substrate is chosen.
- The gap between the two traces is G and the microstrip dipole is fed at the middle of the gap.

3. Result and discussion

The simulation and measurement results of microstrip dipole antenna have been discussed in term of return loss response.

3.1 Analysis of Fix Length and Different Width

In this section, the length of dipole antenna is fixed at 16.53 mm. The width of the dipole is chosen as 3mm, 5mm, 7mm and 9mm. The simulation result is shown in figure 3 and the analysis of the results is shown in table 1. From the table and graph it shown that the wider the width makes the lower frequency resonance of the antenna and the frequency is shifting from right to left. From this simulation, the bandwidth of this four type of different width antenna is quite similar with each others and the bandwidth that can be achieved are from 11.53% to 13.22 %.

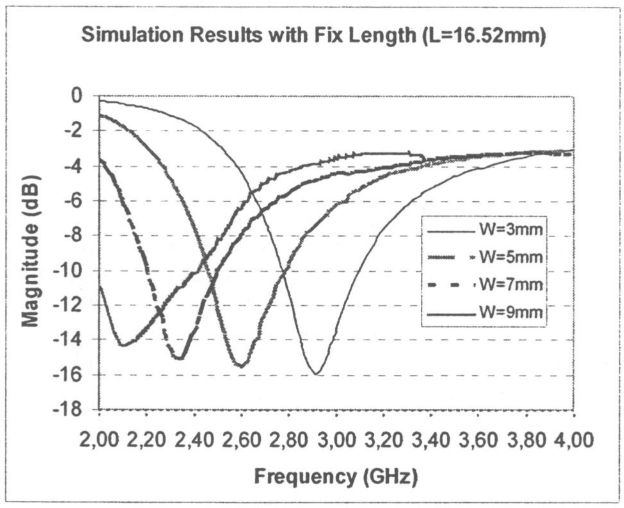

Figure 3: Input Return Loss Results with Fix Length (L=16.53mm)

Table 1: Summary of input return loss results

Length L	Width W	Frequency Resonance	Bandwidth
16.53mm	3mm	2,911 GHz	11.53%
	5mm	2.615 GHz	12.6%
	7mm	2.333 GHz	13.22%
	9mm	2.104 GHz	12.36%

3.2 Analysis of Different Length and Width

In this section, different width and length is chosen to achieve frequency resonance at 2.4 GHz. From the previous results, optimization is made to the length of antenna to get the frequency resonance at 2.4 GHz. The input return loss result is shown in figure 4 and table 1 shows the summary of the results. From the graph it shows that for four different type of analysis have the same frequency resonances at 2.4

GHz. It also shown that the optimization process has been successfully implemented to get frequency resonance at 2.4 GHz.. From this simulation, the bandwidth of this four type antenna is also quite similar with each others and the bandwidth that can be achieved here are from 11.67% to 12.88 %.

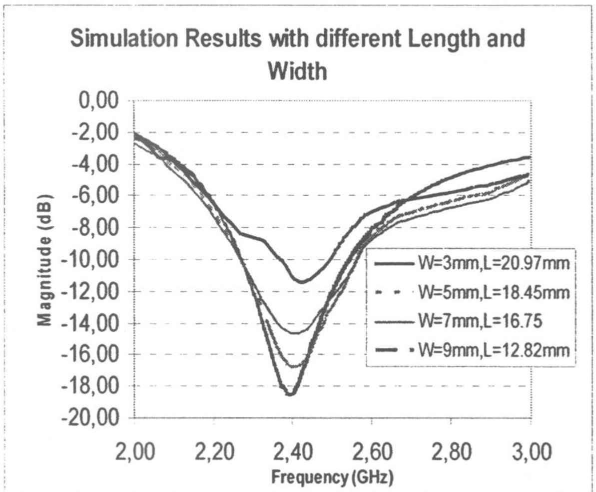

Figure 4: Input Return Loss Results with Different Length and Width.

Table 2: Summary of input return loss results.

Width, W	Length, L	Frequency Resonance	Bandwidth
3mm	20.97mm	2.4 GHz	11.67%
5mm	18.45	2.4 GHz	12.88%
7mm	16.75	2.4 GHz	12.88%
9mm	12.82	2.4 GHz	11.07%

3.3 Analysis of Fabricated Antenna

Three different type of antenna with different width and length have been fabricated and measured. The prototype of fabricated dipole antenna with different width and length is shown in figure 5. The antenna width chosen are 5mm, 7mm and 9mm. The antenna length is the same as previous section.

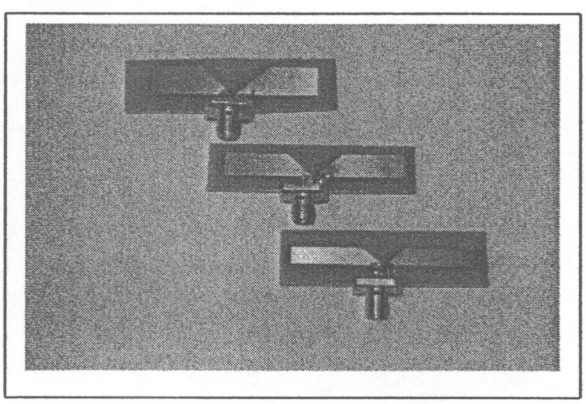

Figure 5: Fabricated Microstrip Dipole Antenna with different width & length.

The measurement results, in term of return loss are shown in figure 6. From the graph, it shown that the frequency resonance of three type antenna fall at 2.16 GHz. This shows that the measurement results have been shifted down from 2.4 GHz to 2.16 GHz. From the measurement results also shown that the bandwidth achieved is about 19 % to 23 %. This shown that the bandwidth achieved in the measurement is much greater than simulation.

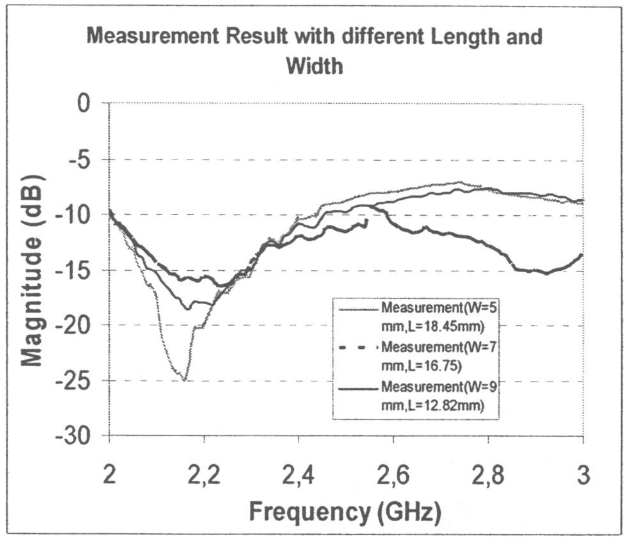

Figure 6: Input Return Loss Results of fabricated Microstrip Dipole Antenna with different length & width.

4. Conclusion

A low cost microstrip dipole antenna for WLAN operations in the 2.4GHz band has been proposed here. The proposed antenna has a narrow width, and is easy to implement. Different type of width and length have been analyze here. From the simulation, the wider the width makes the lower resonance frequency of the antenna. Optimizations also have been done for the length of antenna to get the frequency resonance fall at 2.4 GHz. Different type of width of antenna also have been fabricated and measured here. It shown that the frequency resonance of the antenna has been shifted down to 2.16 GHz. Overall, from the simulation, the bandwidth of microstrip dipole is between 11 to 13 % while for the measurement it can achieve 19 to 23%

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