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Research paper

Design of a Dual Band Coplanar Antenna for WiMax Applications

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Abstract

Ansoft HFSS electromagnetic simulation software was used in this study to simulate the design of two frequency band dual band coplanar antennas for WiMax (3.44GHz to 3.69GHz) and (5.25GHz to 5.85GHz) with center frequencies of 3.5GHz and 5.25GHz respectively. The steps of antenna design simulation are shown in figures of Return Loss, Current Distribution and 3D Radiation Pattern. Through continuous simulation, modification, and correction, the antenna can achieve the desired effect. Metal was used as the reflective material for the antenna designed, the antenna was covered by the material as a partition between the antenna and the metal, and FR4 was used as high-frequency circuit board (dielectric coefficient = 4.4). The simulation and measurement results were found to have consistent and good characteristics.

Keywords: *dual band, coplanar antenna, WiMax.*

1. Introduction

In today's society, the use of smart phones, tablet computers and other 3C products needs frequent access to the internet, and the demand is getting higher and higher at the same time. In many places, there are mobile base stations. People can use the network more conveniently. The network is already a necessity for modern people. Antennas are used to transmit and receive radio signals. Because the services provided by various venues are different, the development of antennas is becoming more and more diverse. Therefore, we designed an easy-to-modify WiMax (3.44 GHz to 3.69 GHz) and (5.25 GHz) ~5.85GHz) two-band dual band coplanar antenna with simple structure that helps reduce the time required for simulation adjustments. Examples include microstrip antenna [1], printed antenna [2] and PIFA [3] etc. The microstrip antenna has been designed in many different types, such as loop antenna, slot antenna [4], patch antenna [5], and inverted F antenna. Design and application can be made according to different characteristics, such as length, thickness, shape, size, weight, etc.; while for electric property, the antenna's radiation pattern, bandwidth [6], polarization, gain, return loss, standing wave ratio (SWR) and various factors shall be considered.

2. Antenna Design and Simulation

This study is designed with the methods of simulation, test, and modification to make the theoretical and actual values consistent. The Ansoft HFSS software used has been widely used in the industry and academic world. Therefore, when using Ansoft HFSS, the structure, parameters, materials and etc. Meet all the design conditions, the measurement benchmarks will be very close to the simulation results. Figure 1 shows the simulation steps for this study.

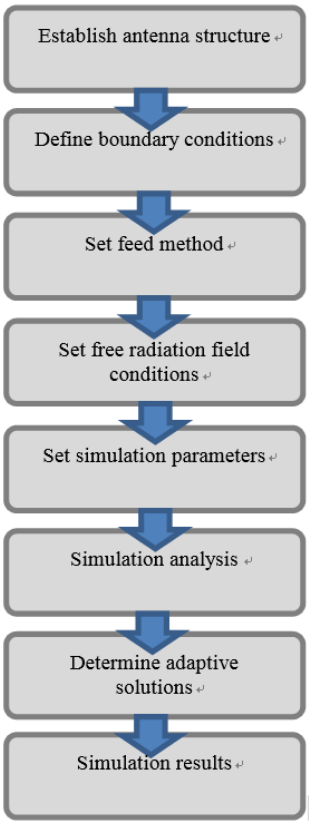

Fig. 1: Simulation steps

1. Establish antenna structure:
The antenna structure is drawn using the models provided by Ansoft HFSS.

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2. Establishing antenna structure:
Ansoft HFSS uses the boundary condition setting function to define the antenna conductor surface as a PEC (Perfect Eletric Conductor) or as a Finite Conductor, both of which are conductor characteristics. The former is a perfect conductor and the latter is a finite conductor. The finite conductor can adjust the antenna conductor surface conductivity and relative permeability. And can define a variety of conductive materials.

3. Set feed method:
The selection and setting of the feed method is one of the important factors in the analysis of the antenna by Ansoft HFSS. There are two feed methods for the antenna: lump port and wave port. However, lump port is usually used for the the microstrip line, while the main feed for our simulation is wave port.

4. Set free radiation field conditions:
Ansoft HFSS is often used for open structures, and the antenna scattering problem is often calculated using Radiation or PML (Perfectly Matched Layer). Due to the large space setting required by radiation, the simulation time is much longer than that of PML. The resulting difference is very small. Therefore, we set the radiation field condition to PML, which can greatly shorten the simulation analysis time, and secondly, when the final result is generated, the radiation condition can be set as radiation to obtain more accurate result.

5. Set simulation parameters:
To use Ansoft HFSS to set the antenna analysis simulation parameters, the solution frequency shall be set at first, followed by setting the number of adaptive solutions. If the adaptive solutions do not occur after the simulation analysis, increase it. Then set the scanning frequency method as Fast, discrete and interpolation. Finally, set the sweep frequency range and start simulation analysis.

6. Simulation analysis:
After the settings are completed, Ansoft HFSS provides a validation check, which makes it possible to confirm the parameter settings are free of errors before the simulation.

7. Determine Adaptive Solutions:
After the Ansoft HFSS analysis is completed, it can be used in solution data to observe the entire analysis situation and determine whether there is Adaptive Solutions. Adaptive Solutions is realized if the last value of the adaptive solutions time is less than the maximum adaptive solutions function.

8. Simulation results:
Finally, take out the antenna-related S parameters and 2D radiation patterns.

As shown in Figure 2, a high-frequency and low-frequency dual band antenna was designed for the size parameters of the dual band antenna in this study. And it was applied to two frequency bands of WiMax (3.44GHz~3.69GHz) and (5.25GHz~5.85GHz). The main dimensions are: L, L1, L2, L3, g, W, W1, W2, S (mm). Figure 3 shows with -10dB as the benchmark, low frequency bandwidth of 2.3GHz ~ 3.6GHz, the lowest point of 3.03GHz and the reflection loss of -24.92dB; and high frequency bandwidth of 4.88 ~ 5.51 GHz, the lowest point of 5.2GHz, the reflection loss of -28.32dB. Therefore, both low frequency and high frequency needed to be adjusted back to the target WiMax (3.44GHz~3.69GHz) and (5.25GHz~5.85GHz).Since the above result (abbreviated as: T1) did not yet reach the optimal design, it was modified (abbreviated as: T2), the values of L1, W1, W2, and L3 were finally adjusted as shown in Fig. 4 (abbreviated as: T3).

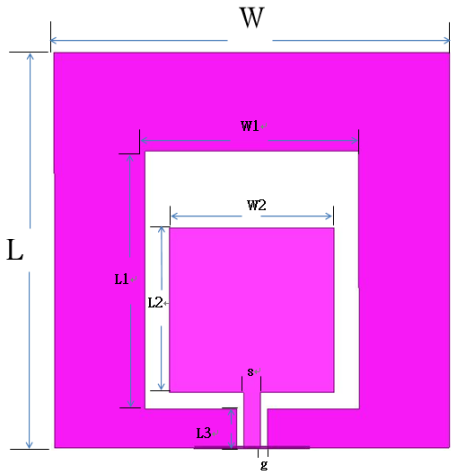

Fig. 2: Dual band antenna dimensional parameter structure

Table 1: Dimensional parameters of dual band antenna structure

Location	Length(mm)	Location	Length(mm)
L	72	W	72
L1	47	W1	39
L2	30	W2	30
L3		7	
g	1.3	S	3

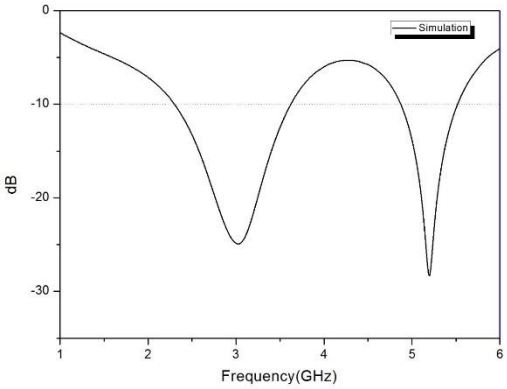

Fig. 3: Dual band antenna return loss simulation

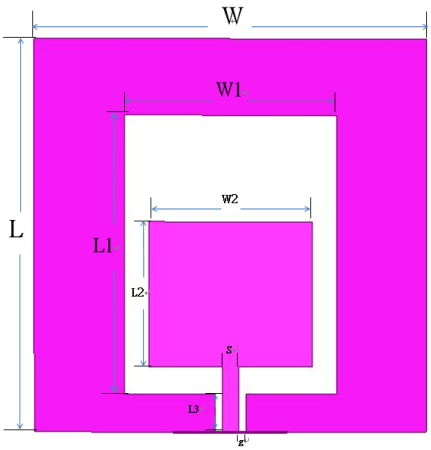

Fig. 4: Modified dual band antenna dimensional parameter structure

Table 2: Modified dimensional parameters of dual band antenna structure

Location	Length(mm)	Location	Length(mm)
L	72	W	72
L1	51	W1	39
L2	26.5	W2	30
L3		7	
g	1.3	S	3

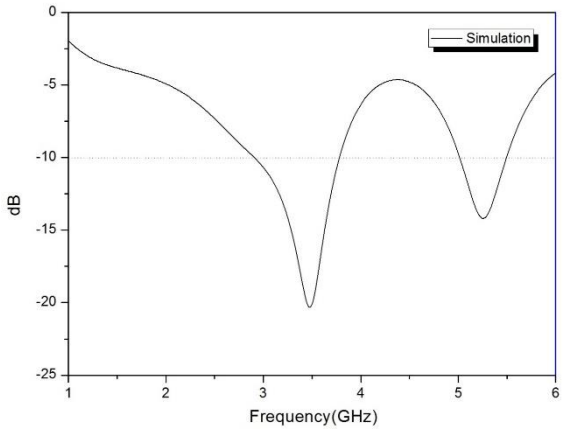

Fig. 5: Modified dual band antenna return loss simulation

Figure 5 shows with -10dB as the benchmark, the low frequency bandwidth of 2.9 GHz ~ 3.78 GHz, the lowest point of 3.48 GHz and the return loss of - 20.33dB; the high frequency bandwidth of 5.01 GHz ~ 5.5 GHz, the lowest point of 5.25 GHz and the return loss of -14.19 dB. This reached the desired frequency band and also eliminated low frequency distortion.

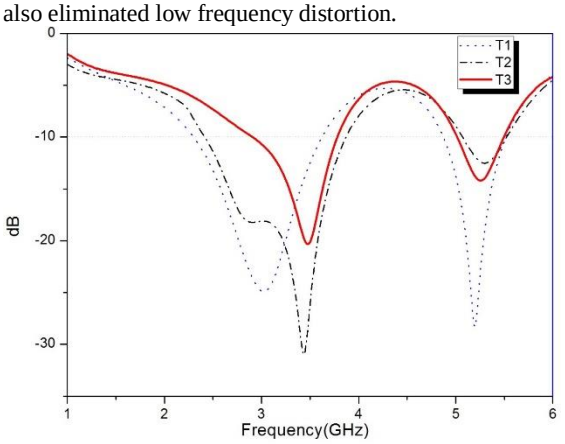

Fig. 6: T1, T2 and T3 antenna return loss simulation

Table 3: Comparison of results of T1, T2, T3

	Low frequency (mm)	Bandwidth (GHz)	Center frequency (GHz)	Return loss (dB)
T1	L1=47, L2=39, W1=30, W2=30, L3=7	2.3~3.6	3.03	-24.92
T2	L1=48, L2=40, W1=30, W2=28, L3=6	2.41GHz~ 3.88	3.43	-12.52
T3	L1=51, L2=39, W1=26.5, W2=30, L3=7	2.9GHz~ 3.78	3.48	-20.33
	High frequency (mm)	**Bandwidth (GHz)**	**Center frequency (GHz)**	**Return loss (dB)**
T1	L1=47, L2=39, W1=30, W2=30, L3=7	4.88~5.51	5.2	-28.32
T2	L1=48, L2=40, W1=30, W2=28, L3=6	5.07~5.52	5.3	-12.52
T3	L1=51, L2=39, W1=26.5, W2=30, L3=7	5.01~5.5	5.25	-14.19

As shown in Figure 6, T1 is the original version, T2 is the modified version, and T3 is the last revised version. It can be seen that the frequency shifts back and forth, and the distortion is also eliminated, reaching the target frequency range.

3. Antenna Simulation and Measurement

In this study, a coplanar dual band antenna was designed with center frequencies of 3.5 GHz and 5.25 GHz. The current distribution and resonance can be seen in Figure 7.

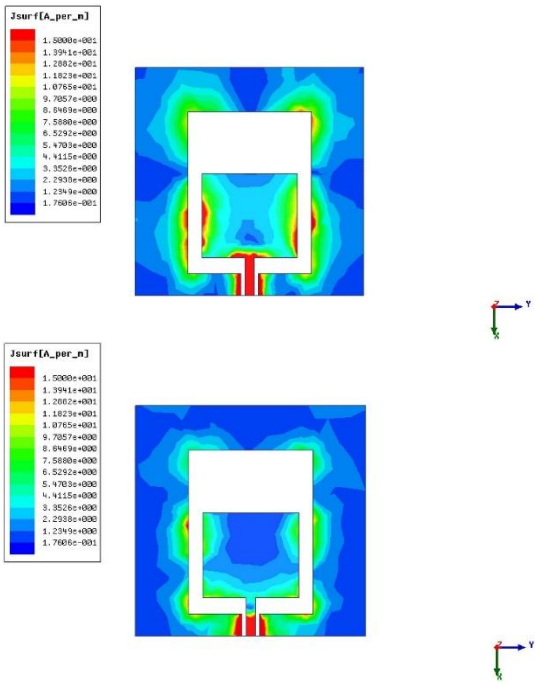

Fig. 7: 3.5 and 5.25 GHz current distribution

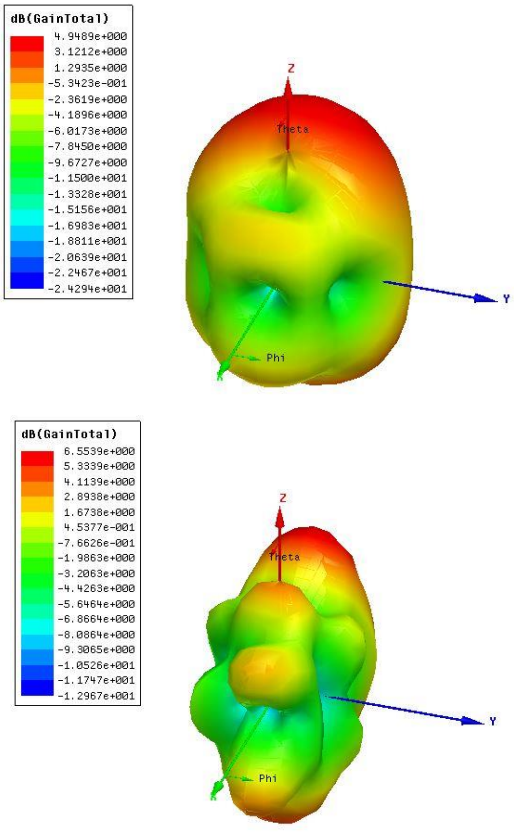

Fig. 8: 3.5 and 5.25GHz 3D simulation pattern

The 3D radiation pattern of the dual band antenna in the XZ-plane at 3.5 GHz and 5.25 GHz is shown in Figure 8. In designing the antenna, we used a coplanar waveguide. Its advantages are low cost and easy fabrication. The plate used was a glass fiberboard (FR4), and a dual band coplanar antenna was fabricated as shown in Figure 9.

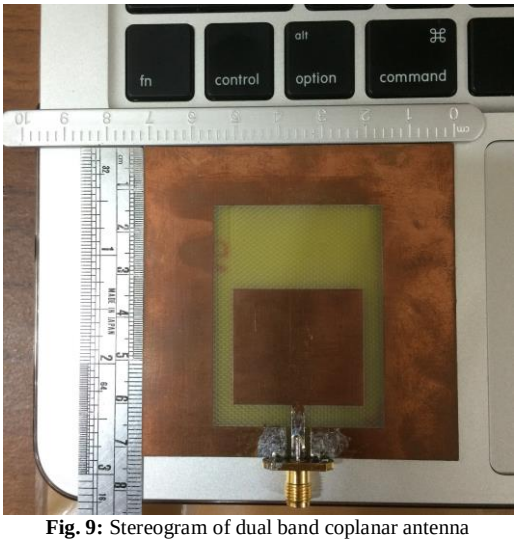

Fig. 9: Stereogram of dual band coplanar antenna

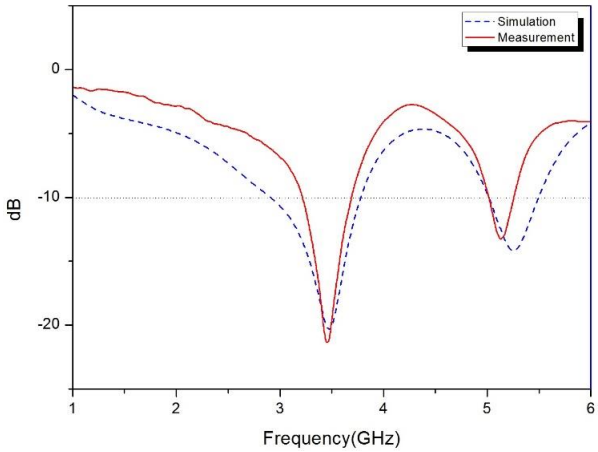

Fig. 10: Comparison of return loss simulation and measurement

As shown in Figure 10, the dashed line is the simulation result, and the solid line is the measurement result. The measured results were based on -10 dB benchmark at low frequencies of 3.22 GHz to 3.69 GHz for the low frequency bandwidth with 3.46 GHz as the lowest point, and -21.34 dB for the return loss; high frequency bandwidth was 5.02GHz~5.26GHz with 5.14GHz as the lowest point, and the return loss of -13.25dB.

4. Conclutions

In this study, we designed the WiMax dual band coplanar antenna using the electromagnetic simulation software Ansoft HFSS for simulation and design. Without any influence, the simulation will be different from the actually measured results. During the research process with repeated simulations and adjustments, we have reached the WiMax (3.44GHz~3.69GHz) and (5.25GHz~5.85GHz) design frequency bands that we needed, and the return loss was also below -10dB. The actually measured results were also very close to the center frequency and bandwidth of simulation, and a better radiation pattern was realized.

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