The Permittivity Frequency-dependent Response of a Ceramic Material to Electromagnetic Waves at 2GHz

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ABSTRACT: The permittivity and permeability can express the electromagnetic properties of the dispersion material. This article presents a novel design of jacket antenna used for measuring the material dielectric coefficient at 2GHz frequency dependent response to the electromagnetic waves. Ansoft HFSS software was also exploited for the calculation. [The Journal of American Science. 2006;2(4):9-11].

Key words: permittivity; permeability; antenna

1. Introduction

The permittivity and permeability suggest the electromagnetic properties of the dispersion material [1]. There are generally two sources of dispersion: material dispersion, which comes from a frequency dependent response of a material to electromagnetic waves; and waveguide dispersion, which occurs when the speed of a wave in a waveguide depends on its frequency [2]. In this article, we design a novel jacket antenna to test dielectric coefficient dependent response to the electromagnetic waves at 2GHz. In patch antenna design, high dielectric coefficient substrate leads to reduce the size of the antenna [3]. However, ceramic material has high dielectric coefficient but is too fragile to measure the dielectric coefficient effect in the range of giga-hertz.

2. Design of Jacket Antenna

The proposed jacket antenna has a clamping microstrip line so that the ceramic material can be clamped coupling with the patch radiator. Tuning stub was printed on the substrate to reduce the inductance of the impedance. Schematic drawing of the design is shown in Figure 1. A 18.56mm×2.9mm×0.4mm, FR4 substrate printed with two slots, one is a T type slot and another one is a wide rectangle slot, formed a parallel plate waveguide feeding system together with the 50 ohm SMA connector and a Π-shaped patch being similar to a pair of palpus, which is 1.5mm thick each, 1mm wide connecting to the microstrip line and 2mm each in length perpendicular to the ground then bended 20mm 45° up.

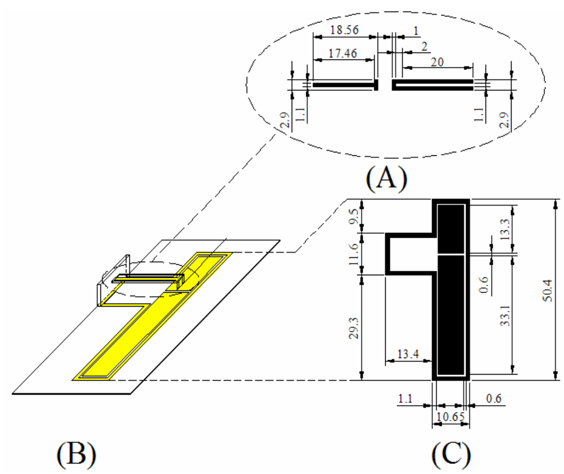

Figure 1. Schematic drawing of the design of the jacket antenna (unit:mm)

Ceramic material can be inserted between the substrate and Π-shaped patch palpus for measuring the effect of dielectric coefficient responded to modulating the operation frequencies of the jacket antenna. By using Ansoft HFSS software, we were able to calculate every different dielectric coefficient modulated operation frequencies of the jacket antenna. In compared with the lab measurement, the dielectric coefficient at the corresponding operation frequency of the jacket antenna can then be found.

3. Results and Discussion

Figure 2 depicted the experimental return loss of the jacket antenna as well as the one calculated by HFSS. In Figure 4, it depicted the experimental return loss of the jacket antenna clamped with a ceramic material and the HFSS calculated one in comparison. Table 1 has listed the bandwidths and the operation frequencies.

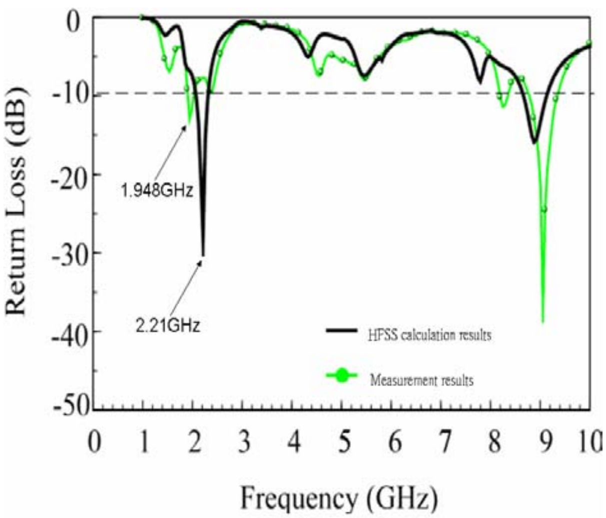

Figure 2. Experimental Return Loss and HFSS Simulation of the jacket antenna

The size of the ceramic material which needs to be tested is a circular one with diameter 4.2mm and thickness 1.73mm. By using HP4284A, the dielectric coefficient of this ceramic material at MHz frequency range is 800 (relative to the air).

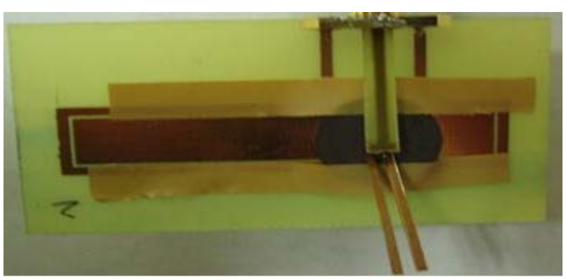

Figure 3. Jacket antenna clamped with a circular shaped ceramic material

Practically, this jacket antenna is dielectric coefficient sensitive because of the coupling of the capacitive characteristic of the design.

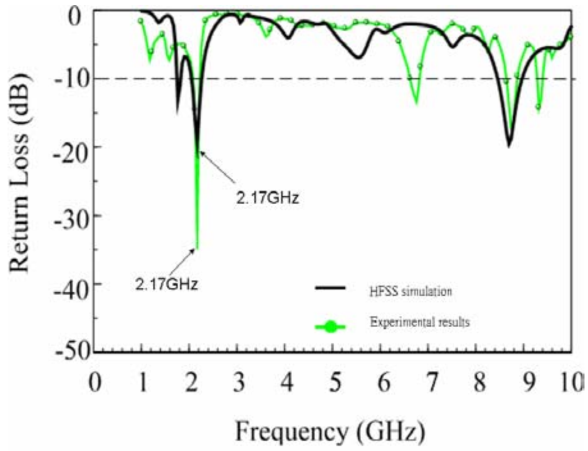

Figure 4. Return Loss of the jacket antenna clamping with a circular shaped ceramic material

Table 1. depicted the design data for the proposed jacket antenna.

	Operation frequency	matching	BW
Exp.	1.95GHz	-13dB	5.65%
Cal.	2.21GHz	-32.27dB	10.85%
Exp + Material	2.17GHz	-33.73dB	6.55%
Cal. + Material	2.17GHz	-19.3dB	9.22%

4. Conclusion

In jacket antenna, the clamping ceramic material affects the operation frequency on upper band being related with dielectric coefficient of the material. This characteristic can be used to test the electromagnetic wave propagating in ceramic material and refers to express the dispersion of the material. In this article, we found that the ceramic material considered is a low loss material. The loss tangent is less than 0.0001. The real part of the dielectric coefficient is about 8 and the conductivity is about 0.96×10^{-4} (S/m). Ansoft HFSS Software is helpful for the calculation.

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References

[1] Huwang, CZ (2002) The study of the measurement of the dielectric coefficient of the material. Master degree thesis in National Central University in Taiwan. (Department of electrical engineering)

[2] Chu, KR (2004) The electron cyclotron maser Rev. Mod. Physics, 76, 489。

[3] Lie, GC (2004) A novel plannar patch microstrip antenna for dual-band wireless communication. Ph.D. Dissertation. National Sun Yat-Sen University, Kaohsiung, Taiwan