Reflection Loss Performance of Triangular Microwave Absorber

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1. Introduction

In recent years, electromagnetic absorbing materials have been increasingly important in ensuring successfully of RF anechoic chamber testing performance. Various researches on enhanced absorber technology have been applied in the testing industry today. Absorbers are one of the main components in an anechoic chamber which is critical in eliminating reflected signals. There are two common absorber categories in the electromagnetic wave range, which is in the microwave range (1 GHz to 300 GHz) and lower frequency range (30 MHz to 1000 MHz). Microwave absorbing materials that are being used in anechoic chambers such as polyurethane and polystyrene are able to reduce reflections of high frequency energy. The usefulness of these microwave absorbers are dependent on testing scopes, either in telecommunication, military, high speed electronics or automotive.

Absorber shape is the main parameter that affects the performance of microwave absorbers. The example shapes are layer type absorber, pyramid, wedge, walkway, convoluted, and oblique absorber. Pyramidal shape absorbers are commonly used for the frequency range between 1 GHz and 40 GHz. In this paper, a new shape absorber is introducing to improve the reflection loss performance compare to the existing shape.

The important thing before selected the material is the dielectric constant and tangent loss of the material. This parameter also can give larger impact to the reflection loss performance. The dielectric constant is a characteristic quantity of a given dielectric substance, sometimes called the relative permittivity. Dielectric constant is defined as the relative permittivity (ε_r) or the absolute permittivity (ε) relative to the permittivity of free space (ε_0). [1] This tangent loss is refers to the dissipation of power or energy from incident waves. [2]

2. Absorber Design

The triangular base microwave absorber designed using CST Microwave Studio software. The design concept for this pyramidal microwave absorber is modification from [3-8]. In this paper, the material of the absorber used is rice husk, a type of agricultural waste. The epsilon, ε_r of this material is assumed to be equal to 2.9 while the tangent loss, $tan\delta$ of this material is 0.084.

Table 1: Dimension of pyramidal microwave absorber with different base

Part	Dimension (cm)		
	Isosceles Triangle	Equilateral Triangle	Square
Base Height	2	2	2
Pyramid Height	13	13	13
Side length	5.6 (2 sides), 5 (1 side)	5.25 (3 sides)	5 (4 sides)

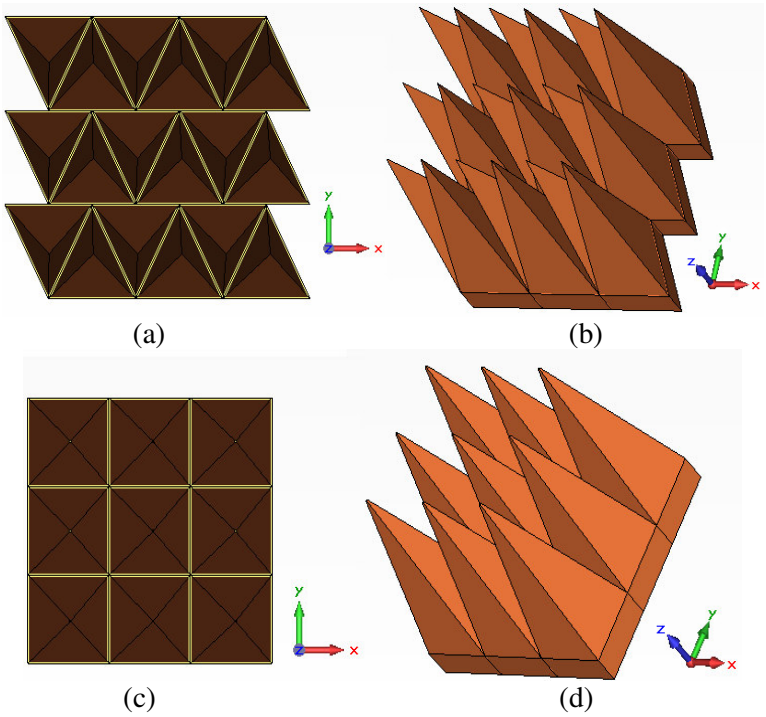

Figure 1: Design of microwave absorber in CST Microwave Studios software. (a) Plan view of array triangular pyramid microwave absorber (b) Perspective view of array triangular pyramid microwave absorber (c) Plan view of array square base pyramid microwave absorber (d) Perspective view of array square base pyramid microwave absorber

Figure 1 and Table 1 shows the dimension of the triangular and square base pyramidal microwave absorber. Isosceles triangle is the triangle with two same sides' length while other one side did not have the same length. Equilateral triangle is the triangle that has the same length for its all sides. Figure 2 shows the parametric study of different side length for triangular base pyramidal microwave absorber design. In this case ten different lengths from 1 cm to 10 cm are considered to compare its reflection loss performance.

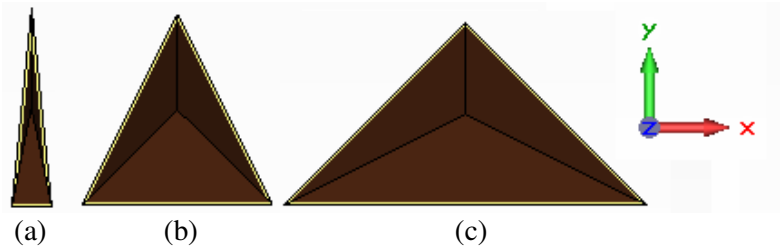

Figure 2: The parametric study of different side length for triangular base pyramidal microwave absorber design. (a) Side length = 1 cm (b) Side length = 5 cm (c) Side length = 10 cm

3. Results and Discussion

Figure 2 and Table 2 shows the reflection loss of triangular and square base pyramidal microwave absorber. From the graph, it shows that isosceles triangle base shows the best average reflection loss result (in the range between 1 to 20GHz) with - 41.142 dB compare with equilateral triangle base only - 39.878 and square base with only -39.423 dB. For frequency range between 0.1 to 1 GHz (low frequency range) it shows that triangle shape base can increase the reflection loss performance compare to square base shape. It achieves - 21.166 dB for isosceles triangle and - 21.839 dB equilateral triangle base. Square base shape only shows performance of - 15.883 dB.

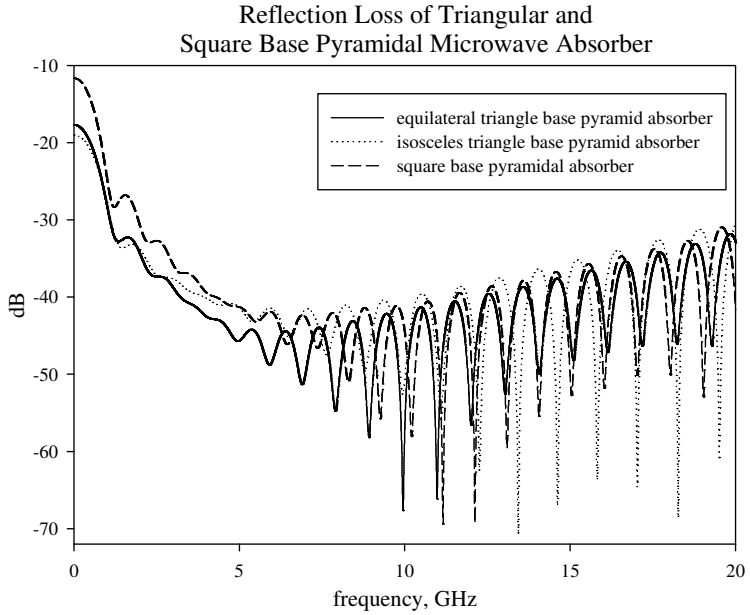

Figure 2: Reflection loss of triangular and square base pyramidal microwave absorber

Table 2: Dimension of pyramidal microwave absorber with different base

Frequency Range (GHz)	Reflection Loss (dB)		
	Isosceles Triangle Base	Equilateral Triangle Base	Square Base
0.1 to 1	- 21.166	- 21.839	- 15.833
1 to 5	- 38.518	- 37.235	- 34.736
5 to 10	- 47.091	- 43.653	- 44.170
10 to 15	- 44.014	- 43.294	- 44.175
15 to 20	- 38.529	- 38.457	- 38.485
1 to 20	- 41.142	- 39.878	- 39.423

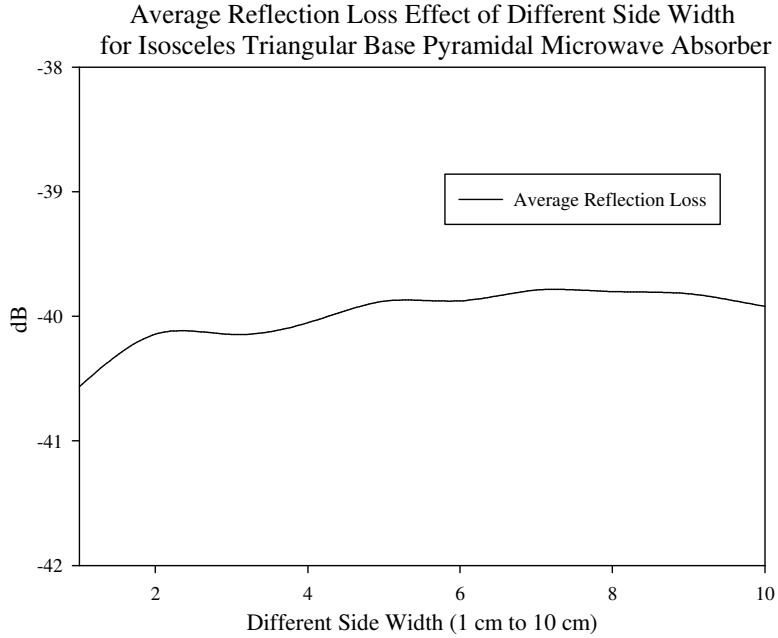

Figure 3: Average reflection loss performance for triangular base pyramid microwave absorber with different side width (from 1 cm to 10 cm)

Figure 3 and Table 3 shows the reflection loss for triangular base pyramid microwave absorber with different side width (from 1 cm to 10 cm). It shows that side length = 1 cm shows the best results with - 40.564 dB while the worst is shown by length = 9 cm with only 39.817 dB.

Table 3: Reflection loss performance for triangular base pyramid microwave absorber with different side width (from 1 cm to 10 cm)

Side Width (cm)	Reflection Loss (dB)					
	0.1 to 1 GHz	1 to 5 GHz	5 to 10 GHz	10 to 15 GHz	15 to 20 GHz	1 to 20 GHz
1	- 20.743	- 36.634	- 46.633	- 43.730	- 38.501	- 40.564
2	- 21.185	- 37.103	- 44.269	- 44.287	- 38.118	- 40.142
3	- 21.440	- 37.080	- 44.047	- 43.752	- 38.907	- 40.145
4	- 21.604	- 37.153	- 44.038	- 43.174	- 38.971	- 40.051
5	- 21.839	- 37.235	- 43.653	- 43.294	- 38.457	- 39.878
6	- 21.879	- 37.314	- 43.394	- 43.545	- 38.422	- 39.879
7	- 21.955	- 37.446	- 43.334	- 43.165	- 38.409	- 39.848
8	- 21.936	- 37.497	- 43.339	- 43.125	- 38.427	- 39.800
9	- 21.970	- 37.591	- 43.377	- 42.976	- 38.481	- 39.817
10	- 22.023	- 37.700	- 43.478	- 43.019	- 38.633	- 39.820

5. Conclusion

The shape can affect the performance of the absorber. In this case, it shows that the triangular base shape shows better performance if compare with the existing and commercial square base shape pyramidal microwave absorber.

References

[1] Bekefi, G. and Barrett, A. H., (1987). Electromagnetic Vibrations, Waves, and Radiation. Cambridge, MA: MIT Press, NEC2 Modeling of Fractal Element Antennae (FEA), pp. 418-420

[2] Neelakanta. P.S., Park J.C., (1995). "Microwave Absorption by Conductor loaded Dielectric". IEEE Trans on Microwave Theory and Technique. Vol 43, No 6, pp 1381-1383

[3] H. Nornikman, F. Malek, P. J. Soh, A. A. H. Azremi, F.H Wee, A. Hasnain, "Parametric Study of Pyramidal Microwave Absorber using Rice Husk", Progress in Electromagnetics Research, PIER 104, pg 145-166, 2010

[4] H. Nornikman, P.J Soh, A.A.H Azremi, "Performance Simulation of Pyramidal and Wedge Microwave Absorbers", 3rd Asian Modelling Symposium (AMS 2009), Bandung, Indonesia, pg 649 – 654, 25th - 26th May 2009

[5] H. Nornikman, P.J Soh, A.A.H Azremi, F.H. Wee, and M.F.Malek, "Investigation of Agricutural Waste as an Alternative Material for Microwave Absorber", Progress in Electromagnetics Research Symposium, PIERS Moscow, Russia, pg 1287 - 1291, 18th - 21st August 2009.

[6] H. Nornikman, P.J Soh, F. Malek, A.A.H Azremi, F.H Wee, R.B Ahmad, "Microwave Wedge Absorber Design using Rice Husk – An Evaluation on Placement Variation", 2010 Asia-Pacific International Symposium on Electromagnetic Compatibility (APEMC 2010), Beijing, China, pg 927 - 930, 12th - 16th April, 2010

[7] H. Nornikman, F. Malek, P. J. Soh, A. A. H. Azremi, "Effect on Source Signal Condition for Pyramidal Microwave Absorber Performance", International Conference on Computer & Communication Engineering (ICCCE 2010), Universiti Islam Antarabangsa (UIA), Kuala Lumpur, Malaysia, pg 289 – 293, 11th - 13th May 2010

[8] H. Nornikman, F. Malek, P. J. Soh, A. A. H. Azremi, S.A Ghani, "Potential of Rice Husk for Pyramidal Microwave Absorber Design", The 2nd International Conference of Institution of Engineering and Technology (IET) Brunei Darussalam Network (ICIET 2010), Bandar Seri Begawan, Brunei Darussalam, 21st - 23rd June, 2010