AN ELECTROMAGNETIC ANECHOIC CHAMBER FOR RADIATED IMMUNITY TESTS ABOVE 1 GHz

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Abstract

An anechoic chamber for radiated immunity tests for low frequency range was modified to extend its frequency range above 1 GHz. Dielectric pyramidal absorbers were used to construct a hybrid absorber consisting of a grid ferrite tile and the pyramidal absorber. The return loss of the hybrid absorber backed with a metal plate was calculated by the simple low-frequency homogenization technique. Experimental results show that the performance of the chamber, i.e., the field uniformity, is good for horizontal and polarizations up to 4.2 GHz except near 190 MHz.

I. Introduction

In recent years there has been a significant increase in the use of radio mobile phones and kinds of RF emitting devices above 1 GHz such as wireless local area networks (WLAN) and personal mobile phones. Accordingly, associated international organizations such as International Electrotechnical Commission (IEC) TC77 has extended the upper frequency of radiated fields immunity tests to 2.6 GHz [1]. However, the upper frequency will soon go up to 6 GHz because of continual increase in mobile communications with higher frequency [2].

Korea Research Institute of Standards and Science (KRISS) has built an electromagnetic chamber for immunity tests in the frequency range of 30 MHz to 1 GHz in 1997. A resonant type grid ferrite tile was used to absorb reflected fields inside the chamber. The lower the level of reflected fields is, the more uniform the test fields on the virtual test plane of 1.5 m × 1.5 m in the chamber. A field is considered uniform if its magnitude over the defined area is within −0~+6 dB over 75 % of the test plane (i.e. at least 12 of the 16 points) [1].

To extend the upper frequency of the immunity chamber above 1 GHz, dielectric pyramidal absorbers are used. A resultant hybrid absorber consists of carbon-doped pyramidal absorbers and grid ferrite tiles backed by a metal plate. We use the method of homogenization [3] to evaluate the reflectivity of the hybrid absorbers before we install actually the dielectric pyramidal absorbers onto inner walls of the immunity chamber. After chamber was lined with the hybrid absorbers, the performance of the chamber for radiated field immunity tests was evaluated by measuring the field strength at 3 m-distance from 26 MHz to 4.2 GHz.

II. The Hybrid Absorber and Its Reflectivity

The low-frequency immunity chamber built earlier is lined with 19 mm-thick grid ferrite tiles so that the chamber meets the field uniformity criterion in 26—1000 MHz-frequency range. Fig. 1 shows the hybrid absorbers consisting of a grid ferrite tile and the pyramidal absorber. The nominal dimension of dielectric pyramidal absorbers is also included to calculate the reflectivity of the hybrid absorber [3]. By applying the frequency domain Prony method [4] to measured permittivity data of the pyramidal absorber [3], the values of each parameter for the Debye dispersion model can be obtained:

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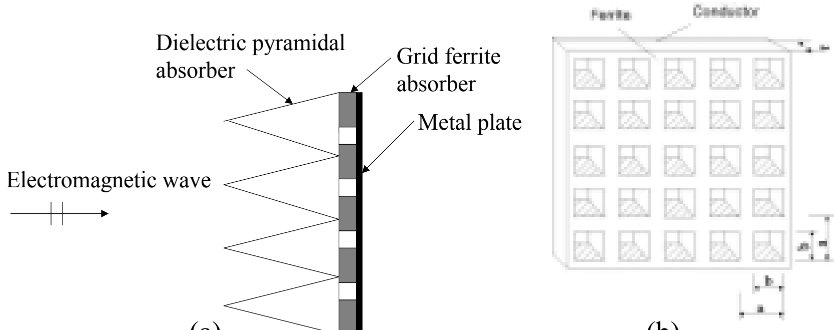


(a) (b) a=20 mm, b=13.5 mm t=19 mm

(Unit: inch)

Nominal overall height	Height of Pyramidal section	Base	Period (p)	Frequency for λ=2p (GHz)
3	2.5	3/4	2	2.5862
5	4.0	1.0	2	2.5862
8	6.5	2.0	3	1.9685
12	10.0	2 1/4	4	1.4764
18	16.0	2 1/4	6	0.9843
24	20.0	4.0	8	0.7382
36	30.0	6.0	12	0.4922
48	40.0	8.0	12	0.4922

(c)

Fig.1. A hybrid absorber and its dimension. (a) A hybrid absorber, (b) grid ferrite tile, and (c) the manufacturer's nominal dimension of the pyramidal dielectric absorber [3].

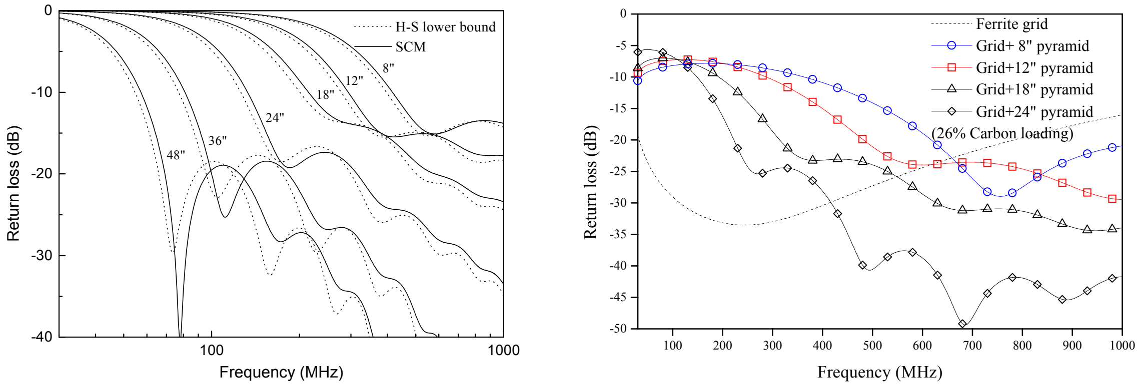
$$\varepsilon_r(s) = \varepsilon_r^{'}(s) - \varepsilon_r^{''}(s) \approx \varepsilon_{r\infty} + \sum_{k=0}^{NP-1} \frac{\Delta\chi_{ek}}{1 + s\tau_{ek}} \tag{1}$$

where s is the complex frequency, $\varepsilon_r^{'}(s)$ is the real part of the relative permittivity, $\varepsilon_r^{''}(s)$ is the imaginary part of the permittivity, $\varepsilon_{r\infty}$ is the optical relative permittivity, NP is the number of poles in the approximation, $\Delta\chi_{ek}$ and τ_{ek} are the strength and the relaxation time of the kth dispersion.

We obtained the reflectivity of the hybrid absorber using the simple low-frequency homogenization technique [3]. Hashin-Strikmann (H-S) lower-bound approximation [5] and the synthesized circuit model (SCM) [6] were compared for 26 %-carbon loaded pyramidal dielectric absorbers. Fig. 2 shows the reflectivity of the pyramidal and the hybrid absorbers with different heights. We presented the reflectivity only in 30–1000 MHz-frequency range since the hybrid absorber performs well above 1 GHz. As observed in Fig. 3(b), the reflectivities of the grid ferrite tile with a 8-inch pyramid and the grid with a 12-inch pyramid are comparable. Therefore, we selected the 8-inch pyramids to maximize the inner usable space of the immunity chamber (its wall-to-wall inner dimension is 8.36 m(L) × 5.94 m(W) × 3.00 m(H)).

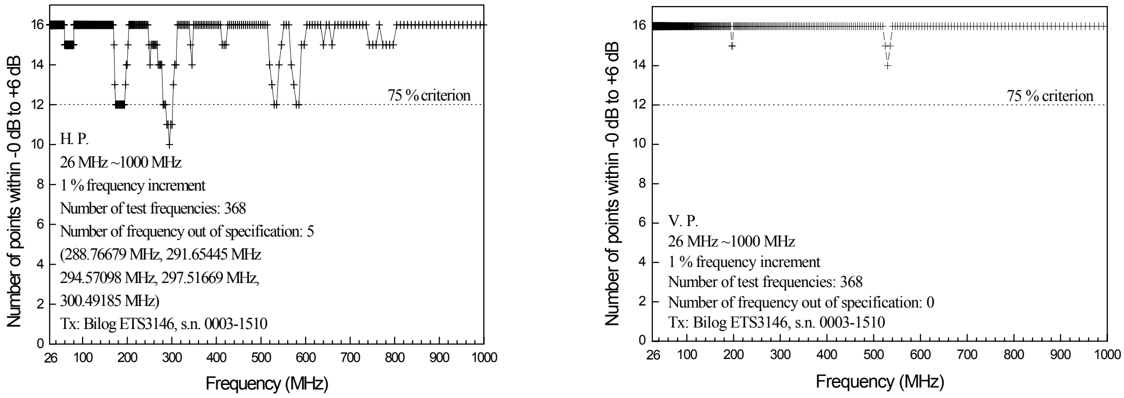
III. Measured Results

After lining the 8-inch pyramids on the grid ferrite tiles, the field uniformity of the chamber was measured according to IEC 61000-4-3 [1] and results are shown in Fig. 3. The



(a) (b)

Fig. 2. Reflectivity of (a) 26 %-carbon loaded pyramidal dielectric absorbers and (b) the hybrid absorber consisting of the grid ferrite tile and the pyramidal dielectric absorber with various heights.



(a) (b)

Fig. 3. Measured field uniformity of the immunity chamber lined with grid ferrite tiles and 8-inch pyramids. (a) For horizontal polarization and (b) for vertical polarization.

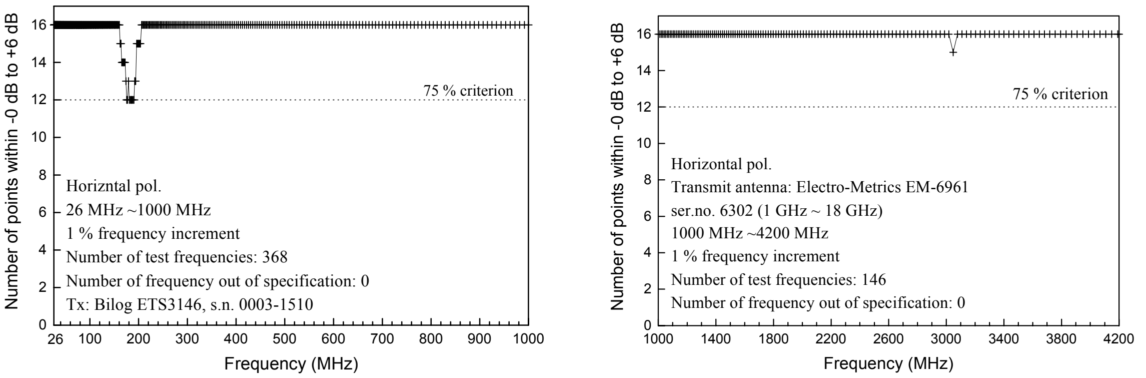
performance of the modified chamber above 1 GHz was excellent and details are omitted.

In order to improve further the field uniformity of the immunity chamber, we replaced the 8-inch pyramids on main specular regions with 18-inch pyramids. The resultant field uniformity shown in Fig. 4 was improved for horizontal polarization in 100—800 MHz-frequency range but deteriorated for vertical polarization in 140—200 MHz-frequency range. This is because the inner space was reduced by lining 18-inch pyramids.

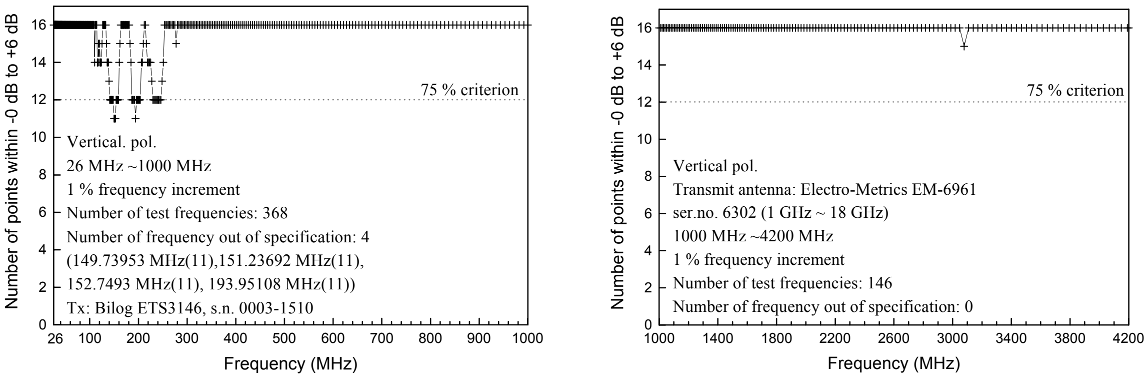
The field distributions at the four frequencies which is out of −0~+6 dB criterion, 149.7 MHz, 151.2 MHz, 152.7 MHz, and 193.9 MHz, meet the relaxed constraint of the field uniformity criterion: a tolerance greater than +6 dB up to +10 dB but not less than -0 dB is allowed for a maximum of 3 % of the test frequencies, provided that the actual tolerance is stated in the test report. Therefore, the modified immunity chamber can be used to perform the immunity test to the rf fields for electrical and electronic equipments.

IV. Summary

We modified the low-frequency immunity chamber to extend its operating frequency above 1 GHz by lining the dielectric pyramidal absorbers on the grid ferrite tiles. To do this, we calculated the reflectivity of the hybrid absorbers using a simple homogenization techniques.



(a)



(b)

Fig. 4. Measured field uniformity of the modified chamber for (a) horizontal and (b) for vertical polarization, respectively. The 18-inch pyramids were lined on the specular zone of the inner walls of the chamber and the rest planes were lined with 8-inch pyramids.

The modified immunity chamber can be used to perform rf fields immunity tests in accordance with IEC 61000-4-3. Although we presented results of field uniformity only up to 4.2 GHz, the modified chamber can be used up to 18 GHz when the operating frequency of a high power amplifier and auxiliary equipments is extended.

References

[1] IEC 61000-4-3, Ed.1.1: Electromagnetic compatibility (EMC) Part 4-3: Testing and measurement techniques, Radiated radio-frequency electromagnetic field immunity test, Nov. 1998.

[2] IEC TC77B/405/CD, Electromagnetic compatibility (EMC) - Part 4-3 : Testing and measurement techniques -Radiated, radio-frequency, electromagnetic field immunity test, Nov. 2003.

[3] C. L. Holloway, R. R. Delyser, R. F. German, P. Mckenna, and M. Kanda, "Comparison of electromagnetic absorber used in anechoic and semi-anechoic chambers for emissions and immunity testing of digital devices," IEEE T-EMC, **39**(1), pp. 33-46. Feb, 1997.

[4] J. N. Brittingham, E. K. Miller and J. L. Willows, "Pole extraction from real-frequency information," Proc. IEEE, **68**(2), pp. 268-273, Feb. 1980.

[5] E. F. Kuester and C. L. Holloway, "Comparison of approximations for effective parameters of artificial dielectrics," T-MTT, **38**(11), pp. 1752-1755, No. 1990.

[6] H. Anzai, M Saikawa, T. Mizumoto, "Analysis of the pyramid electromagnetic wave absorber- An approximated model and its application of TE wave," Trans. IEICE, **78**(3), pp. 191-199, March 1995.