PW (Parallel Wired) cell using pyramid ferrite absorber as a microwave absorber

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Abstract: PW cell is used to test radiated electromagnetic field immunity for small equipment up to frequency of several GHz. As the carbon absorbers as a microwave absorber are conventionally used for PW cell, the inside measurement space is limited to small sized EUT. For the tests in this report, we tried to use a pyramid ferrite absorber, which has been developed recently, instead of a carbon absorber, in order to make the measurement space larger. First, we measured the return losses in the frequency range of 1 MHz – 6 GHz and then found that the return losses by the pyramid ferrite absorber were improved in the range of 40 – 500 MHz, comparing with those by the carbon absorber. Next, we measured the electric field uniformity inside the PW cell respectively at 100, 800 MHz and 2.4 GHz by both absorbing materials, and then found that the uniformity at 100 MHz by the pyramid ferrite absorber was improved similarly as the return loss and that the equivalent uniformity values were obtained by both materials at other frequency points. From the above results, by setting the pyramid ferrite absorber in the PW cell instead of the carbon absorber, it is clarified that the improvement of the reflection coefficients and uniformity as well as the enlargement of the inside measurement space are achieved.

Key words: Pyramid ferrite absorber, Absorber including carbon powder, Parallel Wired Cell, Radiated electromagnetic field immunity test

1. Introduction

As the general measurement method for the electromagnetic disturbances generated from electronic devices and signals of mobile communications equipment, an open area test site, or semi anechoic chamber is used with measurement sensors and antennas. For an open site, we need a vast flat ground as well as fewer incoming (ambient) noises. An anechoic chamber is quite expensive and needs a significant and voluminous space. In addition to the expensive installation costs for the facilities, the inefficient tests involved need large labors and time. In order to solve such problems, the test cells such as TEM cell, GTEM cell and others have been developed.

On such a background, the development has been expected for small size cell which, regardless of its small size, is capable for providing uniform electric field distribution and usable for higher frequency range of several GHz.

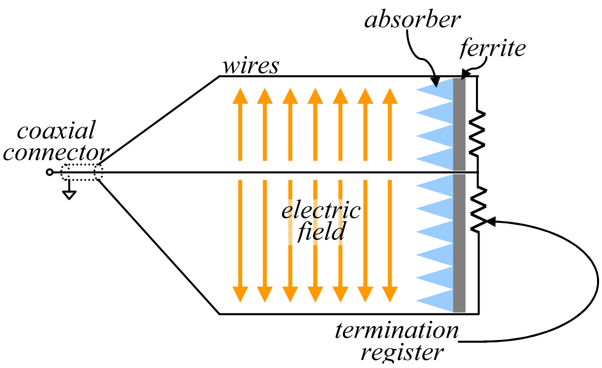
Then, PW (Parallel Wired) cell reported in this research was devised [1]. The PW cell, constructed with central and external conductors of many wires, is capable for suppressing the generation of higher order modes and applicable for easily impressing disturbance noises of high frequency up to several GHz [2]. Moreover, the electromagnetic wave absorbers are put at the termination end of the waves propagating inside the cell. This is for preventing the reflection at the termination end of the direction for the propagating wave, so that the uniform electric field distribution between the central and external conductors is improved.

However, for the conventional PW cell, the carbon absorber was used for the wave absorber, and the available space inside PW cell is small, and the size of the apparatus to be measured is also limited. So in this report, the study was done for the purpose of improving the reflection and electric field distribution characteristics, and of enlarging the available space inside the PW cell by using the recently developed pyramidal ferrite absorber [3][4] instead of the carbon absorber.

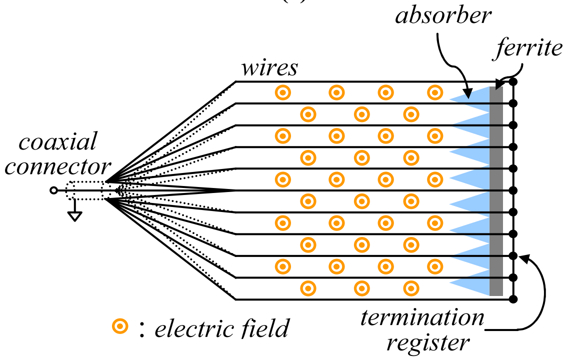
2. PW cell

2.1 Structure of PW Cell

PW cell is the apparatus, which is constructed with central conductor and external conductor of many wires set in parallel, where an electric field is generated by the impressed high frequency signal from the input end consisted of coaxial connector, and where immunity tests of EUT (Equipment Under Test) are performed [1]. The termination end of each wire is connected to the termination resistors to suppress the reflection from the end. Moreover, as the termination resistors do not operate effectively in high frequency range, ferrite materials and absorber are set inside to suppress the deterioration of the electric field due to the reflection from the termination end. Usual PW cell is covered with shielding metal conductors to screen the invasion of disturbance noises from outside and to shield the leakage of the electric field generated inside. On the other hand, the open type PW cell used here is devised to make possible the communications between impressed EUT setup inside and equipment set outside the cell, removing shielding metal conductors. The basic construction of the open type PW cell is shown in Fig. 2.1.



(a) side view



(b) upper view

Fig. 2.1 Construction of the opened PW cell

2.2 Wave absorber

2.2.1 Carbon Absorber

The carbon pyramid absorber as shown in Fig.2.2, 20 cm in height, is made of carbon mixed polyurethane foam. As the material is polyurethane foam, its weight is light and convenient to carry.

Fig.2.2 Carbon Absorber

2.2.2 Pyramid Ferrite Absorber

Fig.2.3 Pyramid Ferrite Absorber

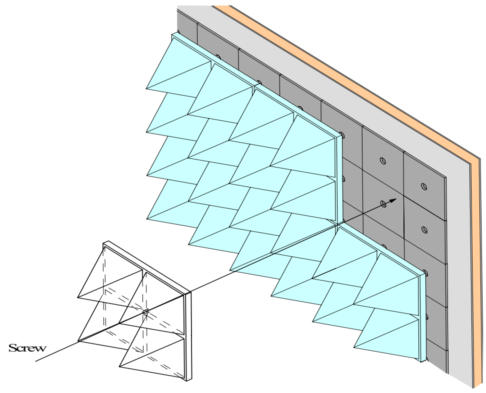


Fig.2.4 Installing method for Pyramid Ferrite

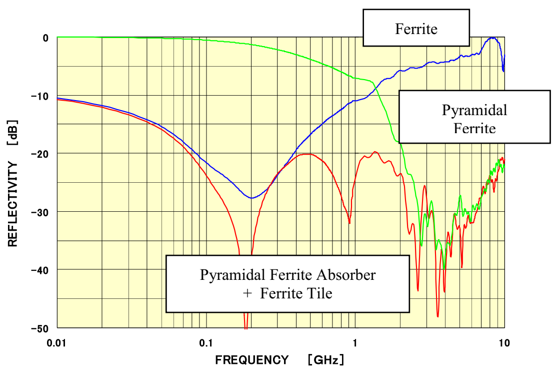


Fig.2.5 Measured Reflection of absorbers

The pyramid ferrite absorber as shown in Fig.2.3 and Fig.2.4 is made of polypropylene mixed with the powder of Ni-Zn-Cu alloyed ferrite and applicable for broad-band noise. As the production is by injection molding, massive production is possible with a high yield rate. The production cost is lowered substantially. More over, the material is hard enough to walk on it. The height of the pyramid ferrite absorber is 8 cm and within 10 cm even when combined with ferrite tiles. The return loss characteristics of the pyramid ferrite absorber applied in an anechoic chamber is shown in Fig. 2.5. It shows that the reflection coefficients for wide range of frequency are improved by using the pyramid ferrite absorber mounted on ferrite tile.

3. Reflection coefficients of PW Cell

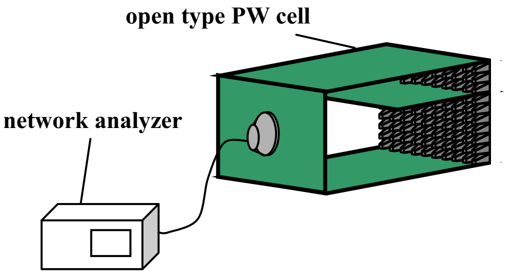


Fig.3.1 Measurement system of the reflection coefficients of PW cell

First, in order to measure the reflection coefficients of the pyramid ferrite absorber, the network analyzer was connected to the open type PW cell and the return loss in frequency range of 1 MHz – 8 GHz was measured. For the above measurement, the ferrite tiles were set on the bottom of both absorbers (carbon and ferrite). In order to compare the conventional carbon absorber with the pyramid ferrite absorber introduced here, the measurements for both absorbers were performed. The measurement system of the reflection coefficients is shown in Fig. 3.1.

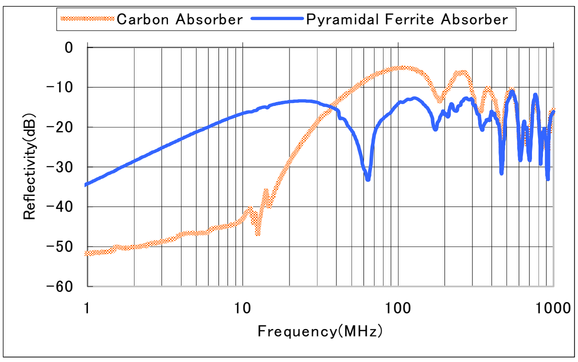


Fig.3.2 Measured values of reflection coefficient

As shown in Fig. 3.2, it turns out from the results that the pyramid ferrite absorber attained better attenuation by about 10 dB or more in the range of 40 – 500 MHz. This is due that ferrite tile's reduction effect was suppressed when combined with carbon absorber, while the tile's effect was maintained when combined with the pyramid ferrite.

4. Electric field distribution characteristics

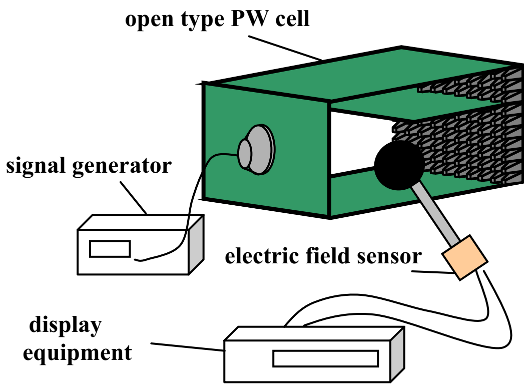


Fig.4.1 Measurement system of electric field intensity

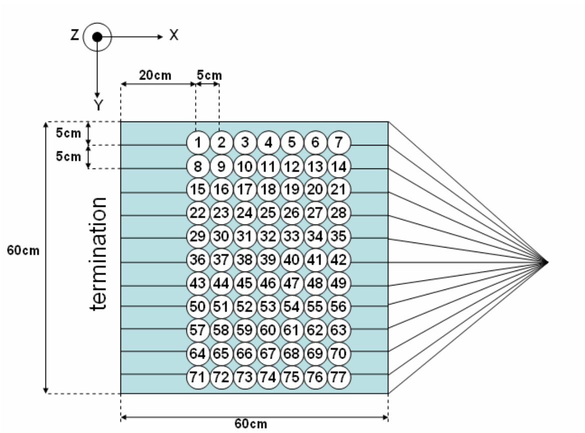
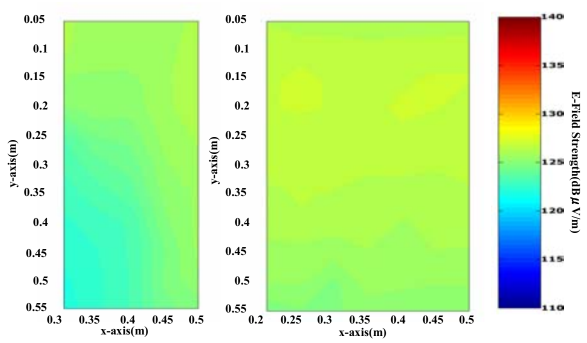
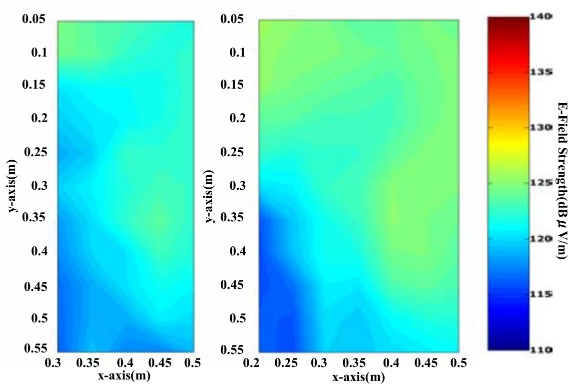


Fig.4.2 Measurement point of electric field

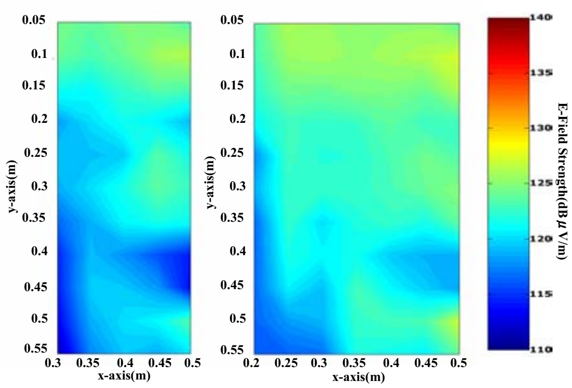
Next, in order to investigate the electric filed distribution characteristics when pyramid ferrite absorber is set, the signal generator was connected to the PW cell and the electric field strength inside the cell was measured. The measurement system of electric field strength is shown in Fig. 4.1. And the outline figure of the measurement points measured by the electric field sensor is shown in Fig. 4.2. The measurement points were set in 5 cm distance each other and on the same plane, totally 77 points. As the termination end is covered with the absorber, in the case of the carbon absorber, 55 points of the columns of #3 – #7 points were measured considering the distance from the absorber, while for the pyramid ferrite absorber, the electric field strength of 77 points through #1 to #77 were measured. Furthermore, the points of 10, 20 and 30 cm in height from the bottom of the cell were measured. Where the main component between central and external conductors is shown as Z direction component, the wire axis direction component as X, and straight crossing direction to the wire axis as Y.



(a)100MHz



(b)800MHz



(c)2.4GHz

Fig.4.3 Electric field distribution characteristics

In order to investigate how wide the uniformity of the electric field strength inside the PW cell, the electric field distributions at 3 frequencies of 100, 800 MHz and 2.4 GHz were measured. A general evaluation method is to check whether the uniformity of the strength in the testing area is kept within 6 dB. As results, at 100 MHz when the pyramid ferrite absorber is used, it was found that the uniformity of the electric field strength inside the cell was improved on every point of a XYZ axis. At 800 MHz and 2.4 GHz, the uniformity with the pyramid ferrite absorber was equivalent to that with the carbon absorber. Although available space is increased by using the ferrite absorber, it was found that the uniformity of the electric field strength was attained.

5. Conclusion

When the pyramid ferrite absorber was used for open type PW cell, it was found that the reflection coefficients were improved in the range of 40 – 500 MHz, and the electric field strength uniformity was also improved comparing with those when the carbon absorber was used. As the ferrite absorber is lower than the carbon absorber by 10 cm, or more, we have larger available space inside the cell for tests by the ferrite absorber. We are able to perform the immunity tests of larger EUT, while we could not put in the cell with the carbon absorber.

Future study assignment is how to apply the pyramid ferrite absorber to GTEM cell, etc, whose available space is limited and narrow due to the height of the absorbers put inside the cells.

References

[1] K. Ishihara and M. Tokuda: "Development of PW cell", IEICE Japan, EMCJ98-112, pp.57-63, 1999.

[2] I. Nakano, E. Kimura, M. Tokuda and K. Ishihara: "Characteristic evaluation of PW cell", IEICE Japan, EMCJ99-62, pp.69-76, 1999.

[3] K. Shimada, T. Hayashi and M. Tokuda : "Fully Compact Anechoic Chamber Using High Frequency Ferrite Pyramid Absorber", International Symposium on Electromagnetic Compatibility, Washington DC, pp.225-230, 2000.8.

[4] M. Tokuda and K. Shimada: "An electric wave anechoic room and EMI/EMC measurement", EMC, No.174, p.116-123, 2002.