A METHOD OF EFFECTIVE USE OF FERRITE FOR MICROWAVE ABSORBER

Youji Kotsuka, Mitsuhiro Amano

Department of Telecommunication Engineering Tokai University, Shonann-campus, 1117, Kitakaname, Hiratsuka-shi, Kanagawa-ken, 259-1292 Japan

Tel: +81-463-58-1211(Ext.4056) E-mail: ykotsuka@keyaki.cc.u-tokai.ac.jp

Abstract — **For demands of various EM-wave absorber, a method of effective use of conventional ferrite for microwave absorber is investigated both by FDTD analysis and experiments. The effects of various kinds of parameters are clarified, particularly for permeability. A new matching characteristic is realized simply by punching out small holes in the conventional rubber ferrite without producing a new ferrite material in the region of the microwaves.**

I. INTRODUCTION

Recently, demands for various kinds of EM-wave absorbers have increased, particularly in the mobile communication field to prevent an incorrect operation, and in an office equipped with a microwave LAN system to suppress multi-reflected waves.

To quickly respond these demands and to effectively use conventional ferrite materials, a simple method of controlling the matching frequency in microwave absorber has been expected. However, in the case of a ferrite absorber, it has not been so easy to realize the EM-wave absorber with the matching frequency that we desire because the ferrite material is manufactured though a complex process under the condition of controlling the sintered temperature, the pressure, the mixing rate of materials etc.

This paper describes a simple method of changing and improving the matching characteristics by punching out small holes in a rubber ferrite, not by adjusting the processing condition for producing a new ferrite material but by the geometrical shape. For the theoretical investigation of the present matching characteristics, FDTD analysis is newly introduced. From the analysis and experiments, detailed matching characteristics taking into consideration various parameters such as hole size, adjacent hole space, rubber ferrite thickness and permeability are investigated. As an example of the application, a double layered absorber below 20 dB in reflection coefficient with multi-holes is obtained at 2.45GHz with a thin thickness of 3mm based on the theoretical data.

II. FUNDAMENTAL CONSTRUCTION AND ANALYSIS

Fig.1 shows the fundamental construction of EM-wave absorber with multi-holes. Small holes are punched out of the rubber ferrite absorbing material and the back is attached to a conductive plate.

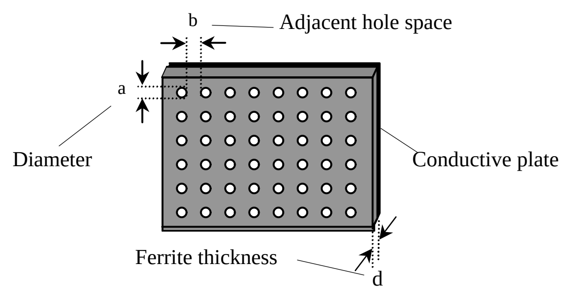

Fig. 1 Fundamental construction of multi-hole microwave absorber.

It is difficult to investigate the present matching characteristics only from an experimental viewpoint because there are many parameters. Accordingly, FDTD analysis is newly introduced to treat the present problem theoretically and to clarify the matching characteristics. Since this analytical model has a periodical structure, periodical boundaries are introduced and at the opposite side of ferrite absorber, a 16 layer PML absorbing boundary is introduced. To reduce memory size for the computer analysis, a circular hole is approximated by square one in the subsequent theoretical investigations. Fig. 2 shows the validity of this approximation. As for the circular hole analysis, a zigzag step approximation is adopted. It is found that a good approximation is obtained in the middle size of circular hole to the square hole as shown in Fig. 2 (b).

Fig. 3 shows the comparison of calculation with measurement result in matching characteristics. Dotted circles show the measured matching characteristic without small holes. Blank circles and

0-7803-6540-2/01/$10.00 (C) 2001 IEEE

triangles show the measurement result in the case with small holes when the 2mm diameter hole and the space between adjacent holes are 3.5 and 9.2 mm, respectively. Solid and dotted lines represent theoretical values in the cases without small holes and with small holes, respectively, using measured permeability and permittivity.

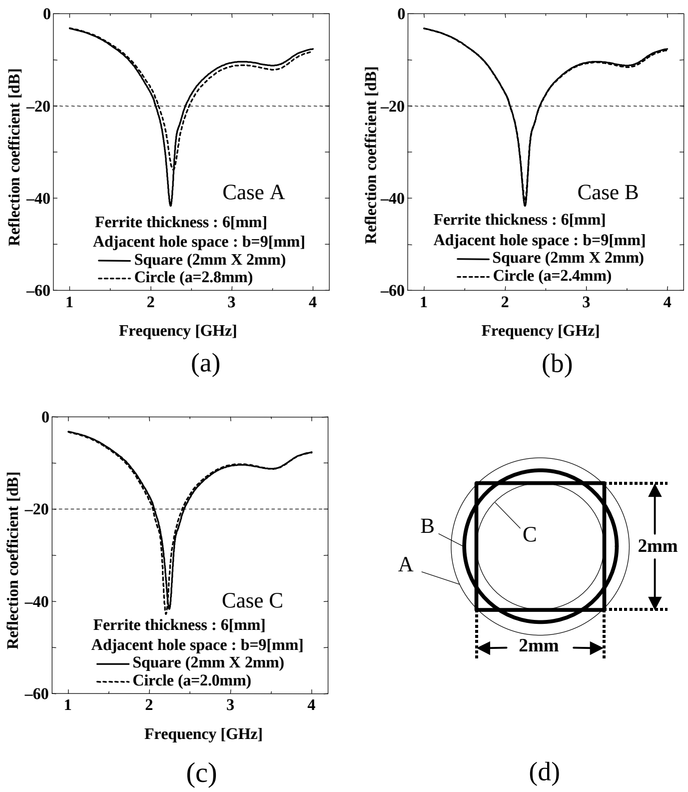

Fig. 2 Validity of approximation.

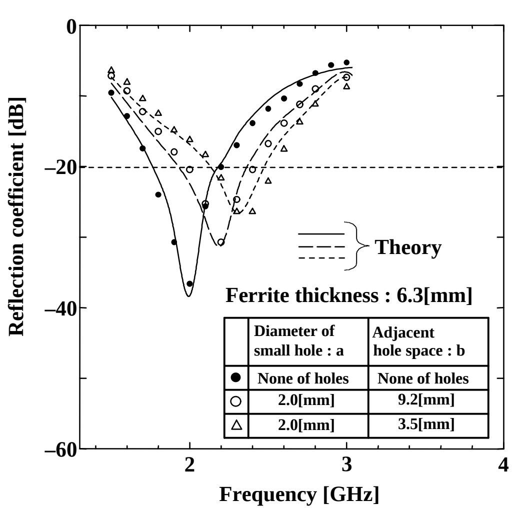

Fig. 3 Comparison of measurement with calculation.

It is found that theoretical and experimental matching characteristics exhibit almost the same tendency.

III. INVESTIGATION OF MATCHING CHARACTERISTICS

A. Effect of size of small holes

Fig. 4 shows the matching characteristics when the size of the square hole are taken as a parameter, while keeping other parameters constant. The space between adjacent holes is 4mm and the ferrite thickness is 6.5 mm. Fig. 5 shows the matching characteristic when adjacent hole space is taken as a parameter.

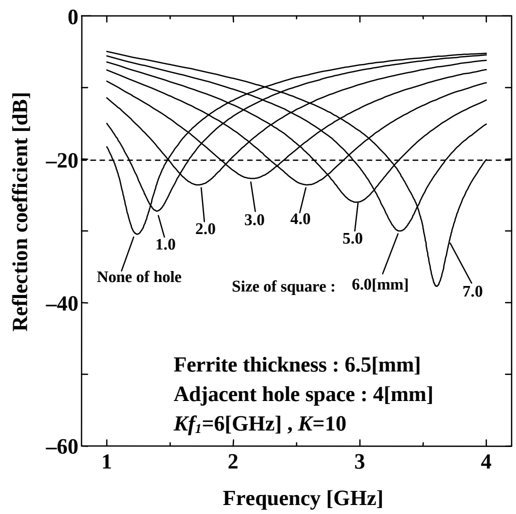

Fig. 4 Effect for size of small holes.

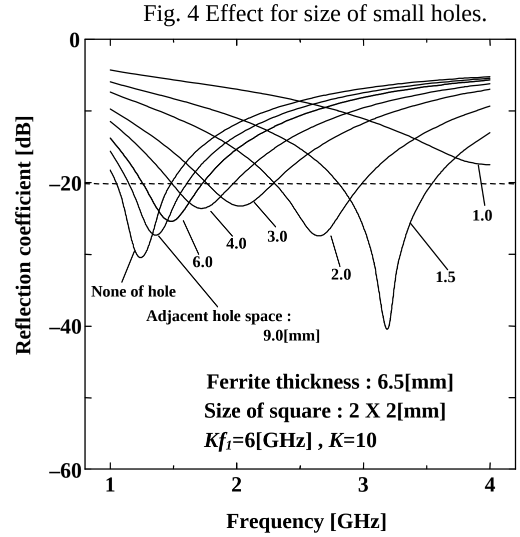

Fig. 5 Effect for adjacent hole of small holes.

Throughout this investigation, a frequency dispersion equation of permeability has been used as the value of permeability as shown in Fig. 6. In this expression, K is the value of static magnetic susceptibility when f is zero, f is the operating frequency, and the limit of Kf_1 is defined as $Kf_1 \leqq 10$ GHz from experimental investigation.

To summarize these theoretical results checked by measurements, simply by punching out small holes in the rubber ferrite, (i) the matching frequency characteristic is changed toward a higher frequency region as the size of small hole increases (ii) the matching frequency characteristic is changed toward a higher frequency region as the adjacent hole space decreases [1], (iii) the matching thickness can be reduced, and (IV) the matching characteristic is improved even if the matching is not obtained with a conventional ferrite.

B. *Effect of permeability*

Fig. 6 shows the cases where Kf_1 is taken as parameters and K is assumed to take extreme values 10 and 10^3, respectively. In this extreme case, the frequency characteristic of permeability is divided mainly into two cases when the real value of permeability takes almost 1 or greater than 1 in the present frequency region.

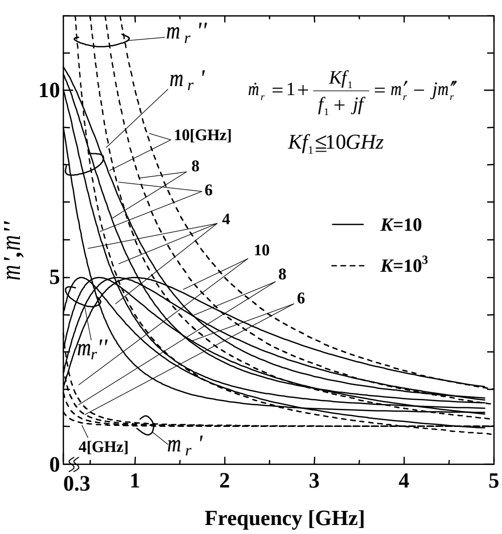

Fig. 6 Frequency characteristics of permeability.

Fig. 7 shows the matching characteristics with small holes when Kf_1 is taken as the parameters, keeping the value of K being 10 and 10^3, respectively. It becomes clear that good matching characteristics are obtained when the value of K is small, even if Kf_1 is changed.

Further, as the value of Kf_1 increases in more than 6 GHz, the matching frequency characteristics deteriorate in the present frequency region. Usual rubber ferrite takes the value from around f_1=6 GHz to 7GHz and small values of K. This is the reason why we chose a rubber ferrite in the present study.

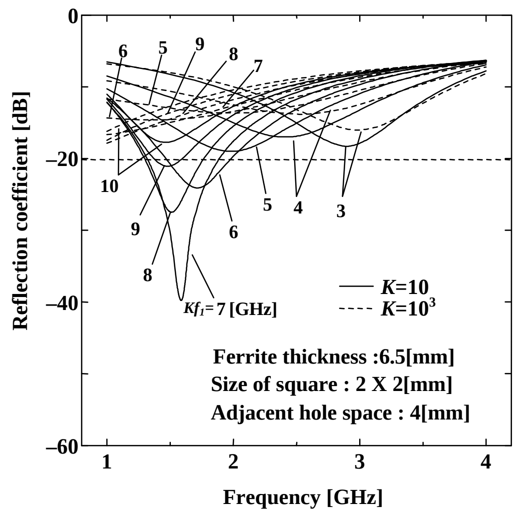

Fig. 7 Matching characteristics taking Kf_1 as a parameter in cases of K=10 and 10^3.

C. *Effect of ferrite thickness*

Fig. 8 shows the matching characteristic with small holes when Kf_1=7GHz and K=10, taking the ferrite thickness d as a parameter. This figure exhibits that the matching characteristic is not obtained when the ferrite thickness is less than 5 mm in the present frequency.

IV. EXAMPLE OF APPLICATION

To design a thin absorber at the frequency 2.45GHz, the idea of multi-hole absorber is applied to a double layer one. As the second material, carbonyl iron material is selected because it maintains a large permeability value, particularly in imaginary part of permeability in the present frequency region. This is based on the following reason. When a ferrite absorber becomes a perfect absorber, the matching thickness d_m is given approximately by the following expression [2].

$$d_m = \frac{l}{2pm''_r}$$

,where l is wavelength and m''_r is imaginary part of permeability. Hence, if the m''_r takes a large value, d_m can be reduced. To adjust the present matching frequency characteristic around 2.45 GHz, small holes are punched out of the double layer absorber based on the suggestion of theoretical simulation.

Fig. 9 shows the matching characteristic with small holes of 2mm in diameter and the adjacent hole space being 3.8 mm. The thickness of rubber ferrite and carbonyl iron is 1.5 mm, respectively.

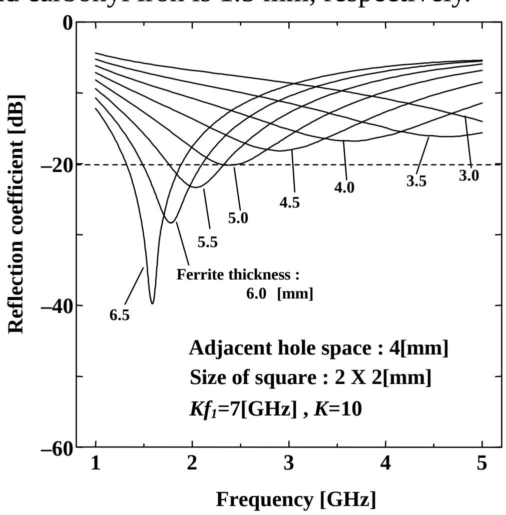

Fig. 8 Matching characteristics of taking ferrite thickness *d* as a parameter.

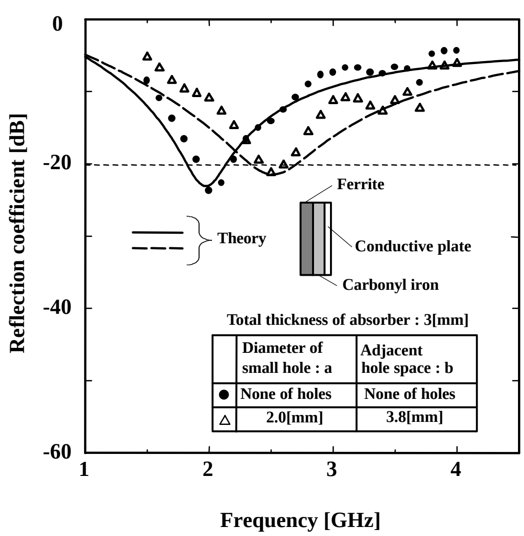

Fig. 9 Matching characteristics of double layer absorber.

V. CONCLUSION

From a viewpoint of an effective use of a ferrite for microwave absorber, detailed matching characteristic using multi-hole rubber ferrite absorber was investigated both by FDTD analysis and experiments. The effect of various parameters for the matching characteristics was examined, particularly for the behavior of permeability. As an application example, double layer absorber consisting of rubber ferrite and carbonyl iron was realized with a thickness of 3mm at 2.45GHz. Consequently, it was clarified that a new matching characteristic is realized simply by punching out small holes in the conventional rubber ferrite without the necessity of producing a new material.

REFERENCES

[1] Y. Kotsuka, " Detailed matching characteristic of a punched ferrite EM absorber," Proceeding of PIERS, Vol. 1, P. 80, July, 1998.

[2] Y. Kotsuka, H. Yamazaki, " Fundamental investigation on a weakly magnetized ferrite absorber," IEEE Trans. Electromagnetic Compatibility, Vol. 42, No. 2, pp. 116-124, May, 2000.