FIELD DISTRIBUTION OF A NEW TYPE OF E.G. MODE ISOLATOR

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Abstract

Experimental investigations into a field distribution around the "short-boundary" E.G. mode isolator proposed by us,are given. From these results, the mechanism of this type of isolator can be made more clear.

Introduction

In the International Microwave Symposium 1975, we proposed a new type of E.G. mode isolator of which circuit structure was shown in Fig.1. In this isolator,no additional electric lossy materials are used as a reverse wave absorber, however, a wide microstrip is shorted to the ground plane at only one edge. The isolation of this type of isolator is fairly large compared to the usual one, and the usable frequency range is considerably wide.

Needless to say, the losses are necessary foe the isolator action, however, the losses of ferrite substrate are not so large in the frequencies apart from the gyromagnetic resonance frequency f_i. The usable frequency range of this type of isolator exists above f_i and approximately equal to a range in which an effective permeability of ferrite $\mu_{eff}<0$. The reason why such a large isolation(for example more than 50 dB) is easily obtained by a small ferrite loss over such a wide frequency range might not be apparent. So, the questions were given on the field distributions around the short edge, at the symposium. Here we discuss about them.

The field distributions around the short edge and along a microstrip are measured by the aid of a small loop antenna. Experimental results show that for a reverse case, the incident wave is almostly absorbed around the discontinuous junction which makes a mode conversion from E.G. mode incident wave into higher order reflected and transmitted waves. Extremely high field points are not found by these measurements. Additionally, numerical calculation utilizing a modal expansion method is done and shows qualitatively the same result. The decay of a fringing field around a microstrip is also measured. These data may be useful for the design of E.G. mode devices, because an estimation of a mutual coupling between the lines is important.

Experimental Results

The measurement of a fringing field around a microstrip was done by means of a small loop antenna (its diameter:4mm) picking up only a magnetic field.

A saturation magnetization $4\pi Ms$ of ferrite slabs are 580 and 1750[Gauss] and D.C. magnetic field Ho of 1000 and 2550[Oe] were applied perpendicular to the ground plane and an operating frequency were 2.45 and 6.0[GHz], respectively. For these case, the insertion loss and the isolation of these circuits were 2.5 and 55 and 5.5 and 50 [dB], respectively.

At first, a loop antenna was moved along the edge of the microstrip. Experimental results are shown in Fig.3(a) and (b) . E.G. mode propagates along the open edge, and hence, when the width of the stripline increases, the amplitude of the field at the other edge decreases exponentially, and vice versa. Fig.3(b) shows such a character of E.G. mode. For a forward case, the incident wave propagates along the open edge almostly without attenuation. On the other hand, for a reverse case, the incident wave encounters the short edge. As a result, many reflected and transmitted waves having high attenuation constant are generated there. The total field attenuates even in the tapered section.

Next, the field distribution in the transverse plane were measured. The difference of the forward and reverse field distribution at y=2.5 [cm] corresponding to the discontinuous junction shown in Fig.4(a) is apparent. The direction of a field displacement for a reverse case is opposite to one for a forward case. But, the two field distributions at y=5.0[cm] shown in Fig.4(b) are similar to each other except a level difference. In the open-short boundary line, a modified E.G. mode is only a propagating mode and its field distribution is approximately equal to E.G. mode's one.

The fringing field decays exponentially and the decay constants for z and x direction are about 1.8 dB/mm and 1.9 dB/mm, respectively.

Numerical Calculation

R.F. field under a microstrip is closely related to the fringing field above a microstrip, however, it can not be measured directly. So, numerical analysis was done for estimating R.F. field at the discontinuous junction.

The incident wave is assumed to be E.G. mode,and the reflected wave and the transmitted wave are expanded by the eigen modes in the open -open boundary line and the open-short boundary line, respectively. The continuity condition of electric and magnetic field at the junction determines the expansion coefficients A_n and B_n.

$$E_{z0}(x) + \sum_{n=0}^{\infty} A_n E_{zn}(x) = \sum_{n=0}^{\infty} B_n E'_{zn}(x) \quad (1)$$

$$H_{x0}(x) + \sum_{n=0}^{\infty} A_n H_{xn}(x) = \sum_{n=0}^{\infty} B_n H'_{xn}(x) \quad (2)$$

For a trancated summation, An and Bn are determined so as to minimize the following squared error;

$$\Lambda_N = \frac{\int_0^a \left| E_{z0}(x) + \sum_{n=0}^{N} A_n E_{zn}(x) - \sum_{n=0}^{N} B_n E'_{zn}(x) \right|^2 dx}{\int_0^a \left| E_{z0}(x) \right|^2 dx} + \frac{\int_0^a \left| H_{x0}(x) + \sum_{n=0}^{N} A_n H_{xn}(x) - \sum_{n=0}^{N} B_n H'_{xn}(x) \right|^2 dx}{\int_0^a \left| H_{x0}(x) \right|^2 dx} \quad (3)$$

Finally, An and Bn are the solution to the following matrix equation;

$$\begin{vmatrix} C_{AA} & C_{AB} \\ C_{BA} & C_{BB} \end{vmatrix} \begin{vmatrix} A \\ B \end{vmatrix} = \begin{vmatrix} D_A \\ D_B \end{vmatrix} \quad (4)$$

Calculated field distributions are shown in Fig.6. Higher order reflected waves rapidly decay and calculated field shows much higher concentration than measured fringing field. However, calculated values agree with measured values, qualitatively. Furthermore, measurement of the internal R.F. field may be necessary.

References

[1] M.E.Hines;"Reciprocal and Non-Reciprocal Modes of Propagation in Ferrite Stripline and Microstrip Devices" IEEE Trans.,MTT-19 pp.442-pp.451, May 1971.

[2] K.Araki et al.;"New Edge Guided Mode Devices" 1975 Int. Microwave Symp. Digest pp.250-pp.253,May 1975.

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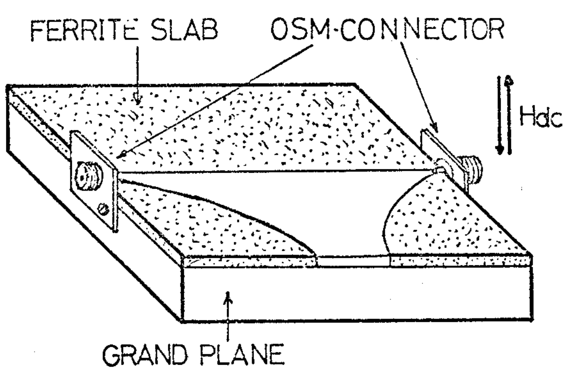

Fig.1 A new type of E.G. mode isolator.

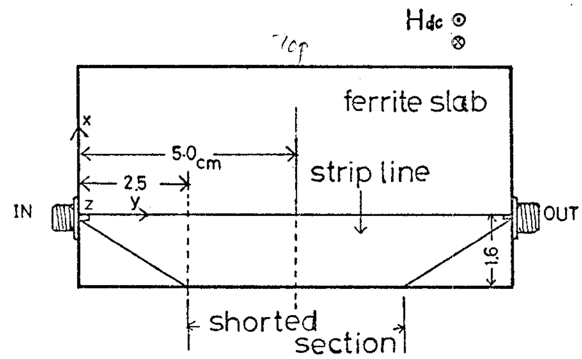

Fig.2 The circuit structure and the coordinate.

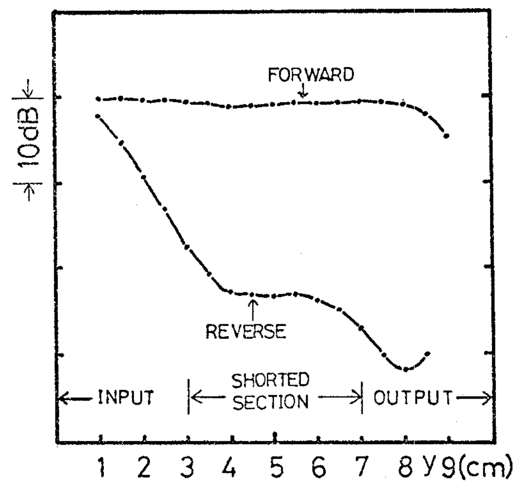

Fig.3(a) Field distribution along the open edge.

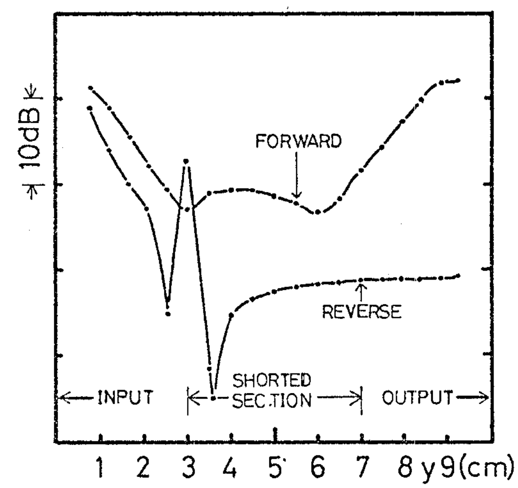

Fig.3(b) Field distribution along the other edge.

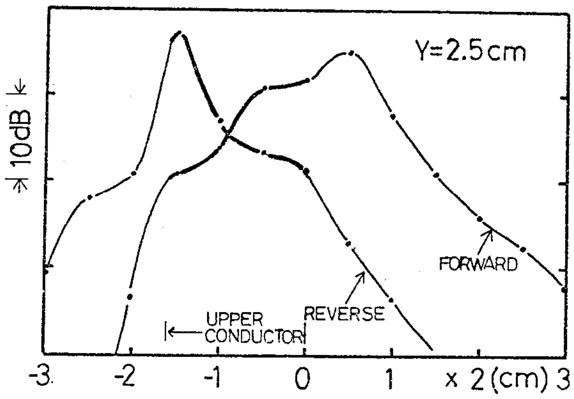

Fig.4(a) Field distribution at y=2.5[cm]

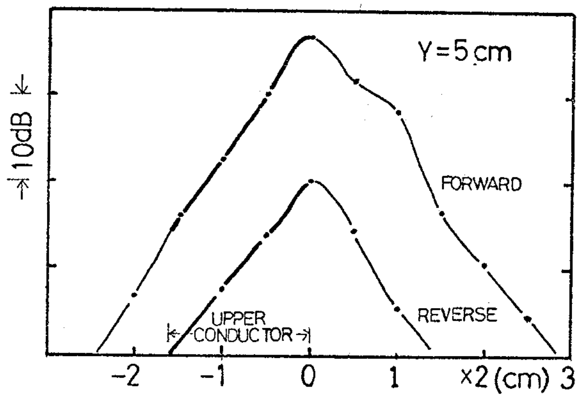

Fig.4(b) Field distribution at y=5.0[cm]

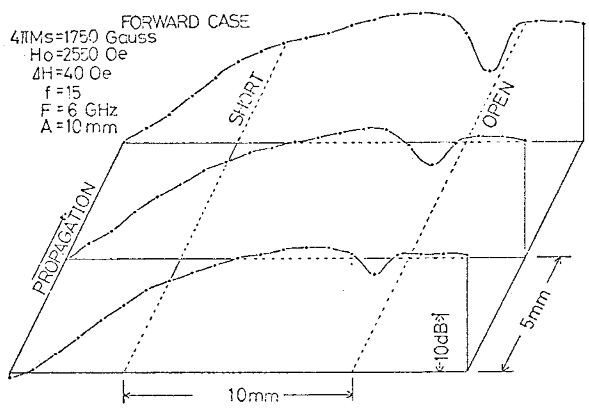

Fig.5(a) Perspective drawing of field distribution (measured)

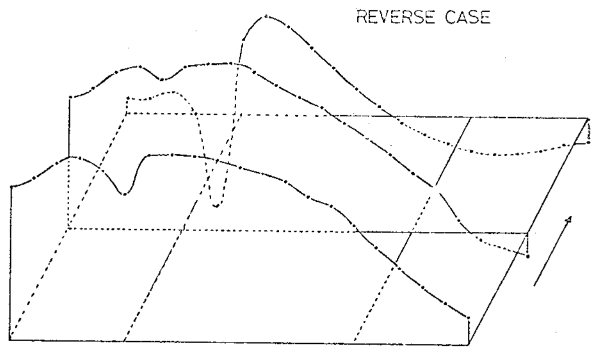

Fig.5(b) Perspective drawing of field distribution (measured)

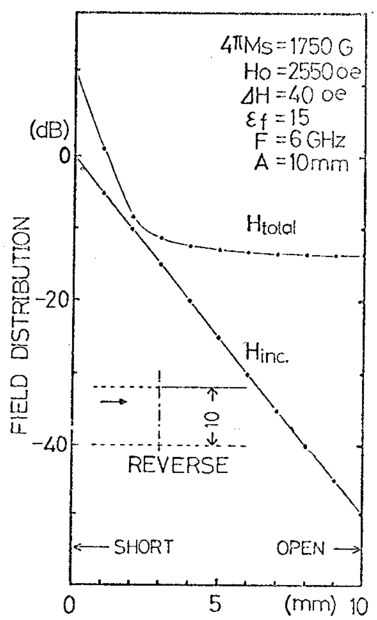

Fig.6(a)

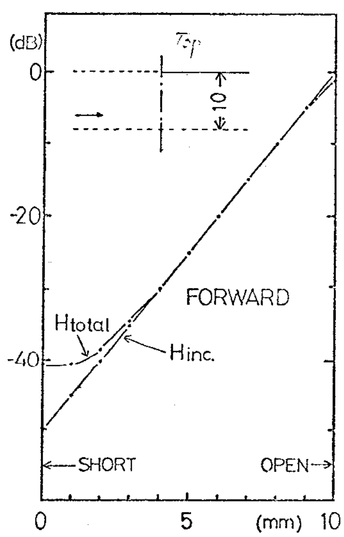

Fig.6(b)

Field distribution at the discontinuous plane (calculated)

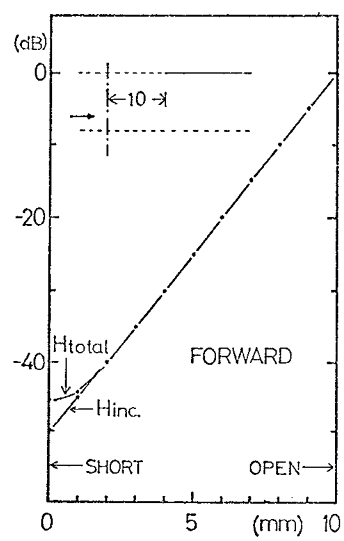

Fig.6(c)

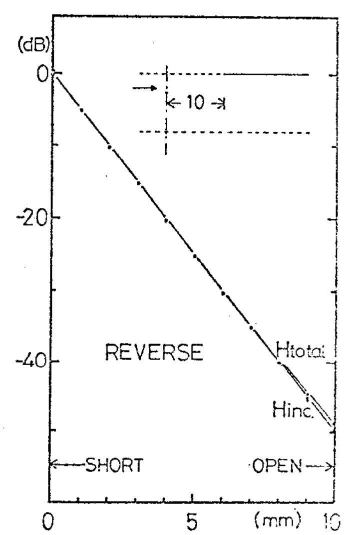

Fig.6(d)

Field distribution in front of the discontinuous plane (calculated)