CIRCULARLY POLARIZED MICROSTRIP ANTENNA USING IN-PLANE BIASED FERRITE SUBSTRATE

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1 Introduction

Many types of circularly polarized microstrip antennas have been studied for a number of communication services such as mobile satellite, terrestrial cellular, and personal communications [1]. However, the path of the wave in such mobile communications can be intercepted by a kind of obstacle under various conditions. This case yields to the condition that we should use the wave reflected by a building or a kind of wall. In case of circularly polarization, the rotating direction of the polarization is reversed and the axial ratio is varied. Since the varied axial ratio depends on the angle of incidence and the material parameters of the wall, we would have to control the polarization to obtain the best sensitivity for a stable communication [2]. However, little report is devoted to the study on such antennas from the viewpoint of the axial ratio controlling.

From the above mention, it would be an important problem to introduce the polarization control technique. As the first step , the authors proposed a circularly polarized microstrip patch antenna whose axial ratio of the polarization is controllable by using in-plane biased ferrite substrate. It is large advantages that the in-plane biased ferrite substrate leads to fabricating small and light ferrite devices with small and weak magnets due to the ignorable demagnetization effect for biasing dc magnetic field. The basic principle of the ferrite patch antenna has been proposed in the last part of [3] and [4] briefly.

In this paper, the authors proposed a ferrite patch antenna structure which is fed by a cross-slot[5][6] using a in-plane biased ferrite substrate. The characteristics of the ferrite patch antenna were investigated experimentally from a quantitative point of view with taking notice of the axial ratio dependence on the bias magnetic field.

2 Experiments

Fig.1 shows the ferrite patch antenna with cross-slot feeding proposed here. The ferrite substrate is an yttrium iron garnet polycrystalline with the saturation magnetization of 800Gauss, and the relative permittivity is about 15. This YIG is biased by a dc magnetic field along the x direction. The dimension of the YIG is 20mm square, and the thickness is 1mm. The 10mm square patch antenna is put on the one side of the YIG. The oppo-

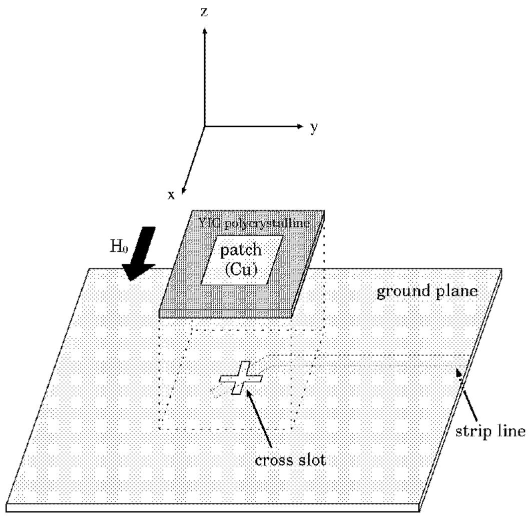

Figure 1: Experimental setup

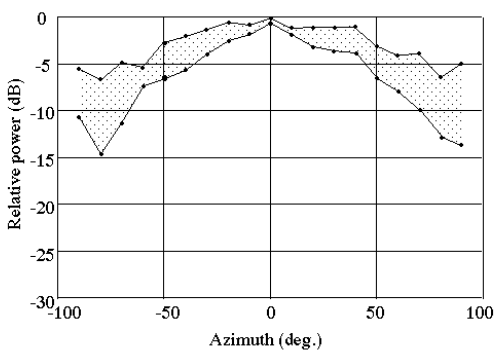

Figure 2: Radiation pattern ($H_0 = 28Oe, f = 4.49GHz$)

site side to the patch is made a direct contact with the feeding cross-slot in the ground plane, which contributes that the field of the feeding microstrip line fabricated behind the ground plane is of no effect on the radiation pattern. The feeding microstrip line is fabricated on the glass epoxy substrate(ε=4.3) with 1.6mm thickness.

Fig.2 shows a radiation pattern which is measured by a spinning dipole antenna in the far field. The measured power is described by the gray zone in the figure which is between the maximum and minimum power. The min-

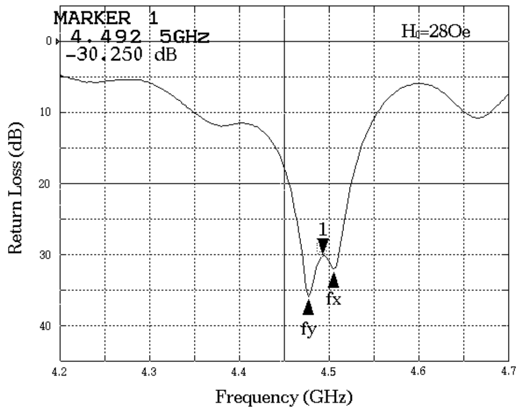

Figure 3: Return loss characteristics

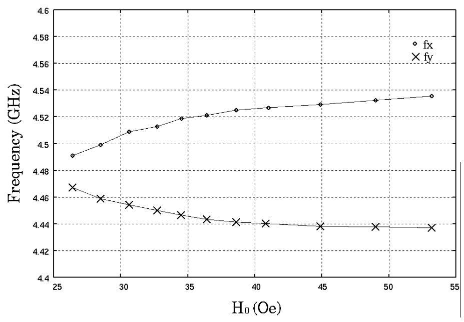

Figure 4: Dependence of the resonance frequency on the magnetic bias field for x and y direction

imum axial ratio was less than 1dB with the dc magnetic bias field of 28Oe. The 3dB axial ratio is achieved within ± 45 degrees.

The return loss is shown in Fig.3 where the fx and fy are the resonance frequency contributing to the polarization of x and y directions, respectively. In case of circular polarization, the phase difference of fx and fy are almost 90 degrees, which is perturbated by the difference of tuning characteristics between x and y direction on the magnetized ferrite. In short, the principle is same as that of the one point feeding technique for circularly polarized microstrip antennas.

Fig.4 shows the dependence of the fx and

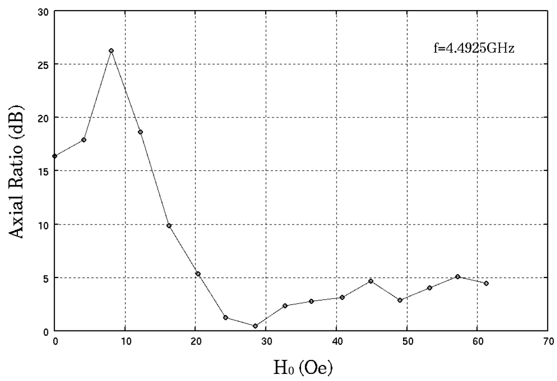

Figure 5: Axial ratio dependence on the magnetic bias field

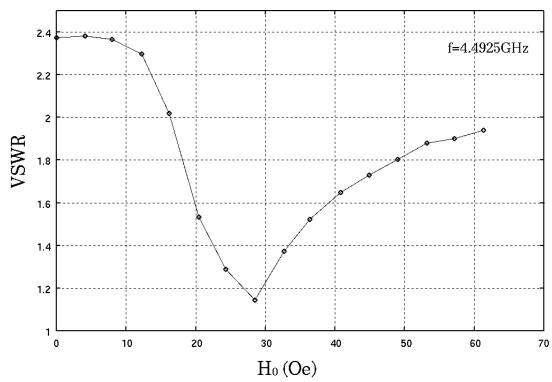

Figure 6: VSWR dependence on the bias magnetic field

fy on the magnetic bias field. As the bias field increase, the fx become higher, however, the fy become lower in low biasing field which is less than 100Oe. Since the ferrite is not saturated sufficiently in such weak magnetic bias, we cannot describe the resonance behavior theoretically using the ordinary tensor permeability. The difference of the behavior of fx and fy would be due to the strength difference of coupling the ac fields with the spin of the electrons in magnetized ferrite.

From the characteristics of Fig.4, we can consider that this antenna radiates the right hand circular polarization (RHCP) in case of applying the biasing magnetic field to x direction. For the left hand circular polarization (LHCP), we should apply the bias field to the y direction.

Fig.5 shows the axial ratio dependence on the magnetic bias field. The minimum axial ratio is realized by choosing 28Oe of the bias field. As increasing the bias field from this value, the long axis of the ellipse polarization become 135 degrees to the x axis with converging to the maximum axial ratio of 5dB. Conversely, as decreasing the bias, the long axis become 45 degrees with being close to the maximum axial ratio of 26dB. In the region where the bias field is less than 16Oe, the SWR is higher than 2 as shown in fig.6. However, in the practical bias field area (>16Oe), the SWR is less than 2, where the axial ratio can be varied within 10dB. This SWR characteristics would be controlled by choosing the length of the cross-slot.

3 Conclusion

The authors proposed a structure of controllable circularly polarized patch antenna and confirmed experimentally the quantitative characteristics of the antenna whose axial ratio is controllable from less than 1dB to 25dB with varying the dc bias magnetic field within 100Oe.

Adopting the in-plane biased structure, we can realize a small ferrite antenna with small bias magnets. The cross-slot coupled feeding technique contributed to the good radiation pattern with one-point feeding, which was not effected by the feeding field on the microstrip line. Using a cross-slot of unequal lengths, we may switch the polarization between RHCP and LHCP in addition to the axial ratio controlling.

One of the important problems to be solved is the theoretical description of the resonance behavior in the unsaturated region of ferrite.

Acknowledgement

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