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Radiation Properties of Ring Microstrip Array Antenna

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1.Introduction

A ring microstrip antenna (R-MSA) has been extensively studied [1]-[6] as an antenna having many advantages. For example, it allows reduction of antenna size. It also allows insertion of an MMIC-circuit module into the inner aperture of an R-MSA element. However, an R-MSA excited by a dominant mode (TM_{110}) has high input impedance characteristics at the feeding point (F). This problem is solved by introduction of electromagnetic coupling in the antenna[3].

In the designing of an array antenna, it is important to estimate the effect of mutual coupling of R-MSAs. Therefore, radiation patterns were estimated by considering the mutual coupling effect[4] of R-MSA elements.

In this paper, active element patterns obtained by computation are presented together with those obtained experimentally. The computed active element patterns agreed well with the experimental patterns of the array fed by electromagnetic coupling.

2.Radiation Properties of R-MSA element and its array

The basic configuration of an isolated R-MSA element is shown in Fig.

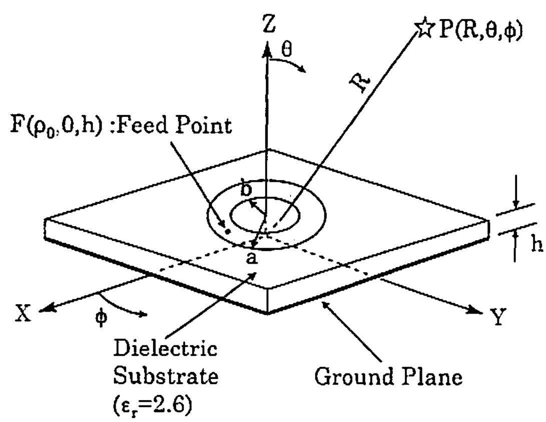


Fig. 1 Basic configuration of Ring-shaped Microstrip antenna (R-MSA)

1,in which the ring ratio(r) of R-MSA is defined as $r = \bar{b}/\bar{a}$, where $\bar{a}$ and $\bar{b}$ are the radii of the outer and inner rings respectively with the fringing effect[6] taken into consideration. Test antennas were fabricated using a Teflon fiberglass substrate (ε_r=2.6, tanδ=0.0018, h=1.2mm), and were tested at the C-band.

As shown in Fig. 2, two equivalent magnetic currents J_{ma} and J_{mb} were excited in the periphery of the antenna excited by a dominant mode (TM_{110}). Considering the mutual coupling between the inner (J_{mb}) and outer (J_{ma}) magnetic currents, the input impedance (Z_{in}) in R-MSA was computed as Fig. 3 using the equivalent circuit of the antenna presented in reference[3]. It is shown that the computed input impedance (Z_{in}) agreed well with the experimental results. The mutual coupling between magnetic currents J_{ma} and J_{mb} was thus found important for the estimation of the input impedance of an R-MSA element.

It is well known that mutual coupling between R-MSA elements is important to estimate the active element patterns of an R-MSA array. Figure 4 shows the configuration of a test 7-element subarray unit composed of R-MSA elements. The active element patterns of the array were computed by considering the mutual coupling effect[4] of R-MSA elements and using the GTD technique[7]. The computed patterns for element Nos. 1,3,4 are shown in Fig. 5(a)~5(c) respectively together with the experimental results. When the mutual coupling effect was taken into consideration and the GTD technique was employed, the computed patterns agreed

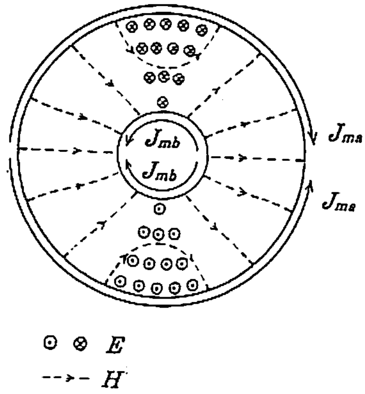
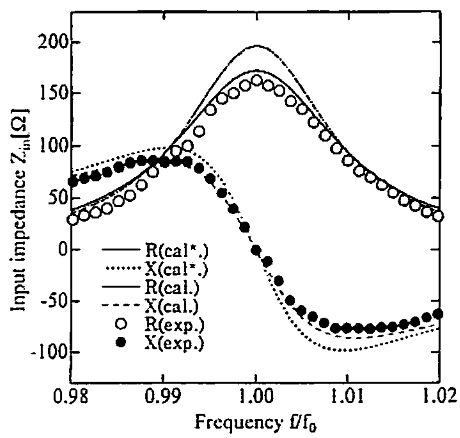


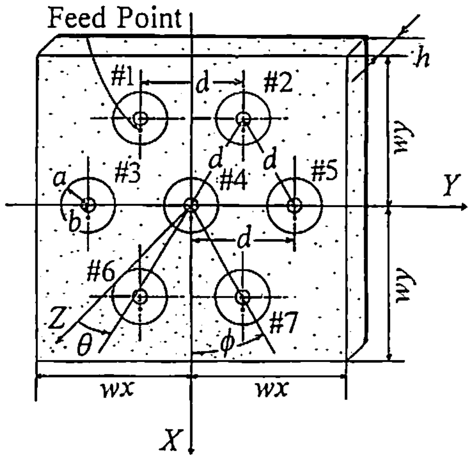
Fig. 2 Magnetic Current Distribution



a=5.99[mm],b=1.51[mm],ρ_0=b
r=0.20,h=0.6[mm],ε_r=2.6

Fig. 3 Input Impedance of R-MSA

*Without mutual coupling between inner Magnetic current J_{mb} and outer Magnetic current J_{ma}



Equilateral arrangement

Fig. 4 Basic configuration of subarray

well with the experimental patterns.

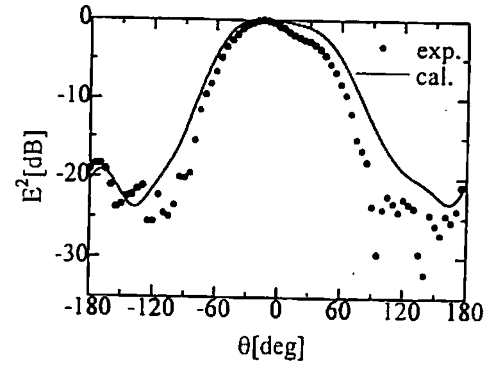
The E-plane radiation patterns of the test array were also computed. An example is plotted in Fig. 6 as a function of scanning angle θ_s. It is found that with an increase in scanning angle θ_s, the peak level is decreased and the side-lobe level is increased.

A large-scale planar array can be produced by integration of a large number of these subarray units.

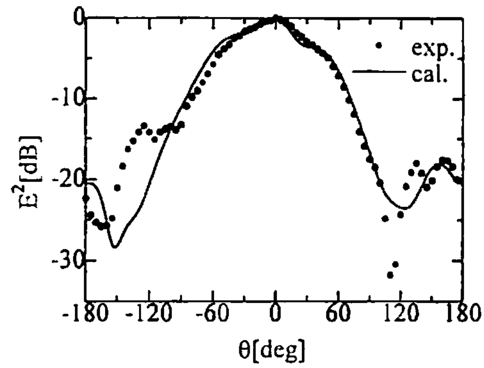
3.Conclusion

In the designing of this type of R-MSA, it is important to consider the mutual coupling of equivalent magnetic currents J_{ma} and J_{mb} or the mutual coupling of R-MSA elements.

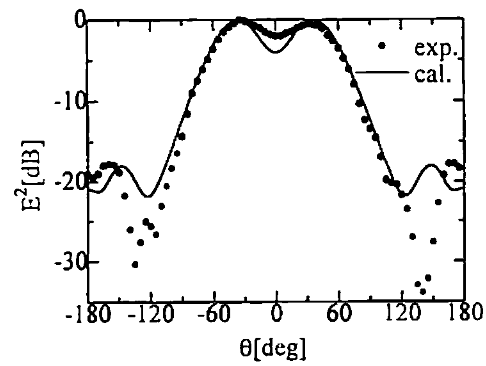
Therefore, Z_{in} in R-MSA was



(a)#1 element



(b)#3 element



(c)#4 element

Fig. 5 An Active element patterns of element antenna(H-pl.)

computed by considering the effect of mutual coupling between two equivalent currents J_{ma} and J_{mb}. On the other hand, the mutual coupling between R-MSA elements was considered when estimating the active element patterns of the array.

The active element patterns obtained experimentally from this planar array agreed well with those obtained from computation. From these results, the R-MSA array presented here is considered to be effectively applicable as a new type of planar array.

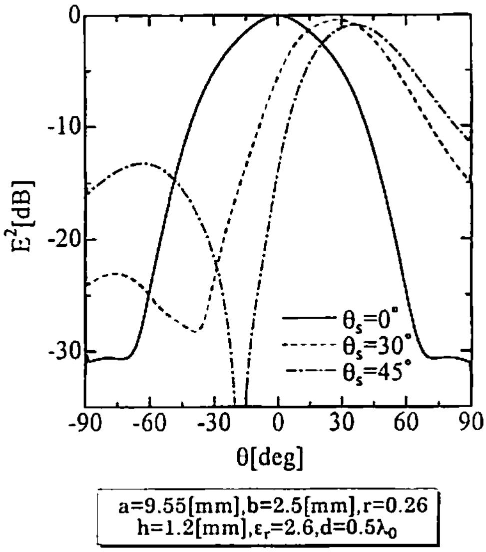


Fig. 6 Radiation patterns of R-MSA array

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