A WIDE BAND RADIAL LINE SLOT ANTENNA

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1.INTRODUCTION

A Radial Line Slot Antenna (RLSA) is a planar antenna for DBS reception[1]. It is a kind of slotted waveguide arrays. The conductor losses are so small that high efficiency is expected irrespective of aperture diameter[2][3]. The efficiency of a large aperture RLSA is much higher than that of other flat antennas of the same size. On the other hand, the bandwidth of RLSA decreases with the antenna diameter due to well known long-line effects of traveling wave antennas. For the application requiring wide-bandwidth, the minimum gain in the band remains relatively low as the antenna diameter increases. This paper proposes a new structure of a radial waveguide to double the frequency bandwidth of RLSA.

2.THE BANDWIDTH OF RLSA

Figure 1 shows the structures of 1-layered[4] and 2-layered[5] RLSAs. Slots on the top plate are arranged so as to radiate the desired polarization in the uniform distribution. Electromagnetic power is fed at the center of the waveguide through a coaxial cable. In a 1-layered RLSA, slots are excited by a radially outward traveling wave. On the other hand, in a 2-layered RLSA, they are excited by a radially inward traveling one transferred at outermost 180° E-Bend. The residual power is terminated by the absorber. Both are operating with traveling wave. Aperture phase distribution is uniform, only at design frequency. The bandwidth of RLSA becomes narrow with the increase of the aperture diameter mainly due to the long line effect of traveling wave excitation feed. Therefore, when the aperture diameter is increased, the gain enhancement at the band-edge is smaller than that at the center frequency.

To evaluate this effect the authors calculated the frequency characteristic of antenna gain for a 1-layered RLSA by array analysis[4]. Figure 2 shows the minimum gain in the band (band-edge gain) as a function of antenna diameters. The experimental results are also plotted and they are in good agreement with the analysis. For the application of wide bandwidth, the band-edge gain is not increasing in proportion to the aperture size[6][7]. It is an essential disadvantage of traveling wave antennas.

3.THE WIDE BAND RLSA

3.1.STRUCTURE

The bandwidth can be improved by reducing the line length. The authors propose a new feed structure for RLSA shown in Fig.3. The power is fed at the center and the outward traveling wave is excited. At the divider, the power is divided into two components, radially outward and inward traveling waves. Each of them excites the slots. The line length of each region is about half of the original one and the long line effect is reduced. Hence the bandwidth increases. In this structure, different slot arrangement patterns are used in the inner (uniform slot length)[5] and the outer part (not uniform slot length)[4] of the aperture. The study of practical slot arrangement, which takes the phase shift at the divider into account, is left for further study.

3.2.POWER DIVIDER

The power divider is designed and evaluated by FEM[8]. The analysis model is shown in Fig.4. The followings are required:

(1)The reflection at the input port (P_r/P_i) is sufficiently reduced.

(2)The desired power division ratio (P_2/P_i) is realized.

Figure 5 shows a power ratio of outward traveling wave (P_2/P_i) as functions of W1 and W2. A hatched region corresponds to the appropriate value of W1 and W2 for which the reflection (P_r/P_i) is less than -20dB. In this example, permittivity ε_r of 1.0 is assumed. It is also confirmed that power division ratio and reflection coefficient are stable over more than 1GHz[9]. This analysis demonstrates the feasibility of the power divider satisfying the conditions (1) and (2) above.

3.3.BAND-EDGE GAIN OPTIMIZATION

We estimate the improvement of the band-edge gain for this wide band structure. Both the position of the divider and the power division ratio are optimized. Aperture integration of continuous illumination is applied for gain calculation[10], where the aperture illumination takes into account of the frequency characteristics of slot coupling[4][5] as well as the terminated loss power. At the design frequency, aperture fields are uniform everywhere while different behavior on the frequency is expected in the aperture of 1-layered and 2-layered regions. Figure 6 shows 800MHz band-edge gain in the RLSA of 80cm diameter as functions of inward power ratio (P_1/P_i) Ein and the location of the power divider.

The optimum gain is obtained in the same manner as a function of diameter. Figure 7 shows the 500MHz, 800MHz band-edge gain as a function of aperture diameter. The band-edge gain for this structure is much higher than that without the divider, and the band widening effect of this structure is numerically confirmed.

4.CONCLUSION

This paper presents a new feed structure for RLSA to improve the frequency bandwidth. As the antenna diameter increases, the band-edge gain of traveling wave antenna is limited because of the long line effect. The new feed structure consists of two feed regions and the line length is halved. The effects of this structure are numerically confirmed. For example, 800MHz band-edge gain of 80cm antenna increases by 4.5dB to 36dBi. The design of practical slot arrangement is left for further study.

ACKNOWLEDGEMENT

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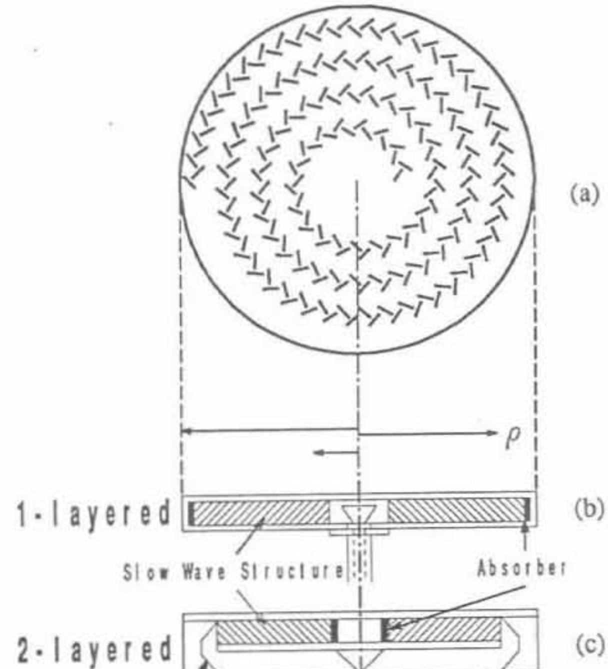

Fig.1 Radial line slot antennas
(a)Slot arrangement for circular polarization.
(b)1-layered feed structure.
(c)2-layered feed structure.

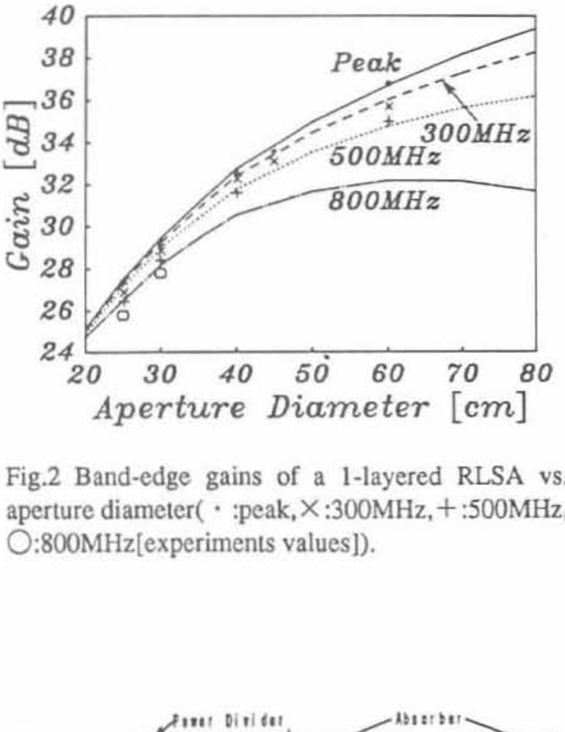

Fig.2 Band-edge gains of a 1-layered RLSA vs. aperture diameter(· :peak, × :300MHz, + :500MHz, ○:800MHz[experiments values]).

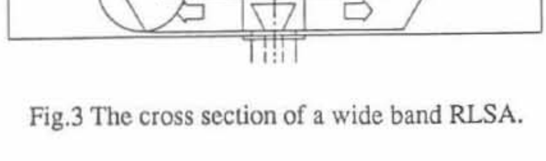

Fig.3 The cross section of a wide band RLSA.

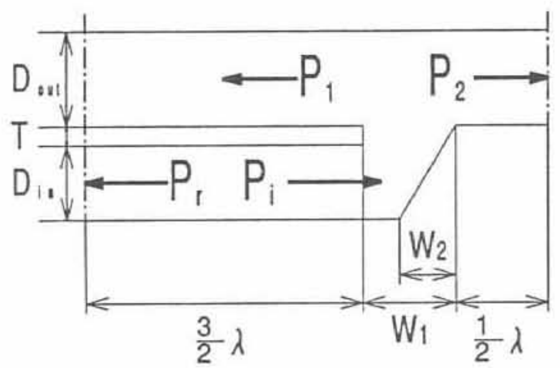

Fig.4 An analysis model of a power divider for a wide band RLSA.

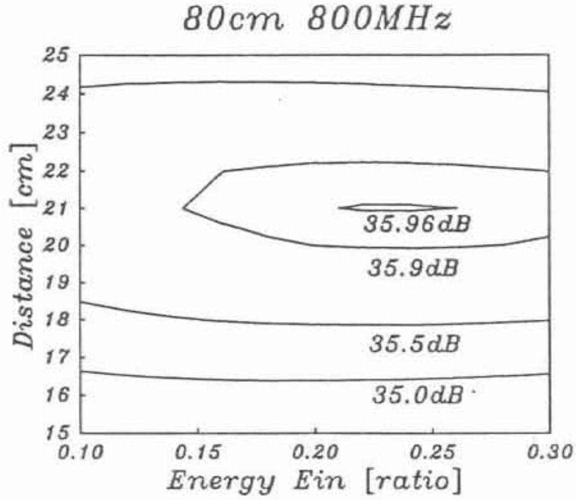

Fig.6 The 800MHz band-edge gain for 80cm diameter as functions of the inward power ratio and the location of the divider.

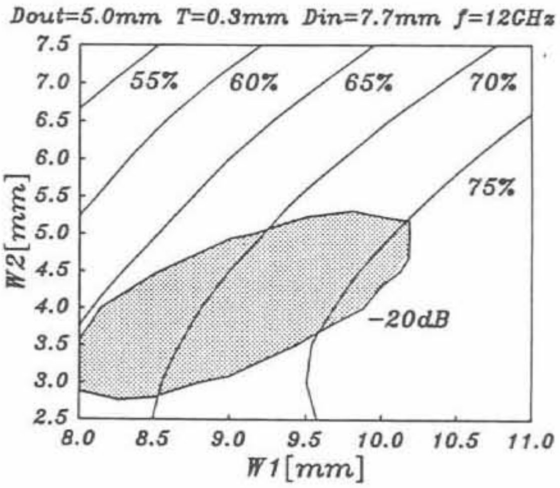

Fig.5 Outward power ratio at the divider and -20dB reflection as functions of W1 and W2.

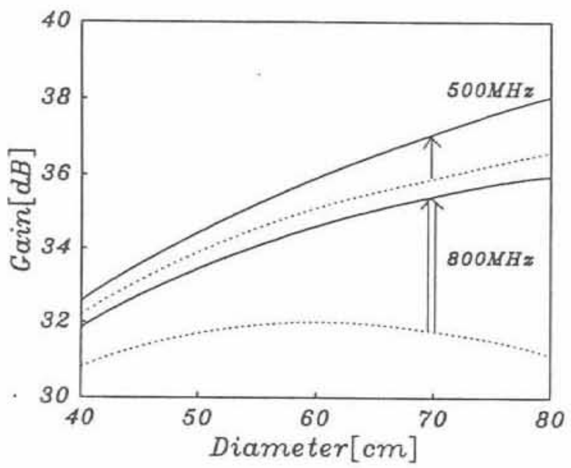

Fig.7 The band-edge gain for the wide band RLSA (solid line) and for the conventional one (dotted line).