CURL ARRAY ANTENNA FOR DBS RECEPTION

H.Nakano, S.Okuzawa, K.Ohishi, H.Mimaki, and J.Yamauchi

College of Engineering, Hosei University
Koganei, Tokyo, Japan 184

INTRODUCTION

In microstrip patch antennas, perturbation elements are required for generating a circularly polarized wave (CPW). As the frequency becomes higher, the size of the perturbation elements is reduced. This size reduction gives rise to difficulty in constructing the perturbation elements [1].

This paper presents a novel CPW radiator without perturbation elements, designated as a curl antenna. The radiation characteristics of the curl antenna are numerically analyzed using the method of moments. In addition, an array antenna composed of the curl elements is described. It is demonstrated that the curl array antenna can be used as a DBS receiving antenna by virtue of its high gain.

CURL ANTENNA

Fig.1 shows the configuration of a curl antenna. The antenna is made of a thin wire of radius ρ, which is bent at a height h and curled above a ground plane. The antenna consists of vertical and horizontal linear sections and a curled section.

The curl antenna has an open arm configuration as opposed to a conventional loop antenna, which has a closed arm configuration [2]. If a traveling current flows along a curl whose mean circumference is on the order of one wavelength, a CPW can be generated. For this reason, the curl proper starts at a radius of 0.134 wavelengths.

The current distribution along the curl antenna is numerically analyzed by the method of moments. The analysis shows that a traveling wave current flows towards the arm end with a relative phase velocity p being close to one. The phase progression is shown in Fig.2.

The radiation characteristics can be calculated using the current distribution. A 3-dB axial ratio criterion is evaluated to be 6.7%, as shown in Fig.3. The antenna gain is found to be about 8.5 dB, which is comparable to the gain of a low-profile helical antenna [3]. The input impedance is a nearly pure resistance of 170 ohms.

Fig.4 shows radiation patterns for the curl antenna. The radiation patterns are slightly asymmetrical with respect to the antenna axis. This is due to the asymmetrical configuration of the curl antenna.

CURL ARRAY ANTENNA

A DBS receiving antenna should have high gain (on the order of 30 dB). An array technique, therefore, is used for the construction of the DBS receiving antenna. Investigating the mutual effects between array elements is a key aspect of the array antenna design.

The degree of the mutual effects can be evaluated by using the decoupling factor (DCF) [4]. Fig.5 shows the DCF versus the separation distance between the curl elements. In this case, the horizontal linear sections of two elements are parallel to each other. As expected, the decoupling increases, as the separation is widened. It is found that a decoupling factor of 22 dB or greater is obtained at separation distances of more than 0.6 wavelengths.

Based on the above-mentioned results, a curl array antenna consisting of 168 elements is constructed, as shown in Fig.6. The bottom of the vertical linear section of each curl element is inserted into a radial waveguide. It should be noted that the insertion length can control the amplitude of the electric field at the aperture. Also, mechanical rotation around the element axis (vertical linear section) can adjust the phase of the electric field at the aperture [5].

The measured frequency response of the antenna gain is shown in Fig.7, together with the aperture efficiency η. It is noted that the maximum value of the aperture efficiency is 95%.

CONCLUSIONS

A novel CPW radiator designated as a curl antenna is numerically analyzed and the radiation characteristics are presented. The curl shows wideband performance for the axial ratio, gain, and input impedance.

Using the numerical results, the curl elements are arrayed on a radial waveguide. The curl array antenna has a high gain of 31.3 dB with an aperture efficiency of 95%, making it appropriate for use as a DBS receiving antenna.

REFERENCES

[1] H.Nakano, et al., "Singly-fed patch antenna radiating a circularly polarised conical beam," IEE Electron.Lett., Vol.26, pp.638-639, 1990

[2] H.Nakano, "A numerical approach to line antennas printed on dielectric materials," Computer Physics Communications, 68, pp.441-450, 1991

[3] H.Nakano, et al., "Extremely low-profile helix radiating a circularly polarized wave," IEEE Trans., Antennas Propagat., Vol. AP-39, No.6, pp.754-757, 1991

[4] H.Nakano, et al., "Radiation characteristics of short helical antenna and its mutual coupling," IEE Electron., Lett., Vol.20, pp.202-203, 1984

[5] H.Nakano, et al., "Low-profile helical array antenna fed from a radial waveguide," IEEE Trans., Antennas Propagat., Vol. AP-40 (to be published in March Issue, 1992)

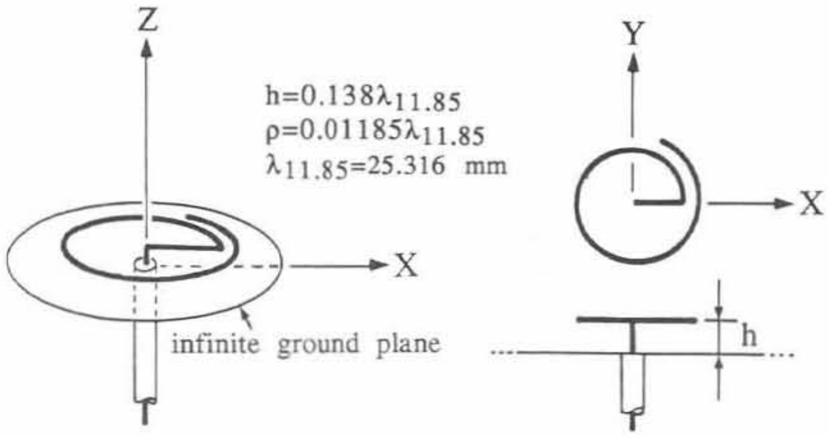

Fig.1 Configuration of curl antenna

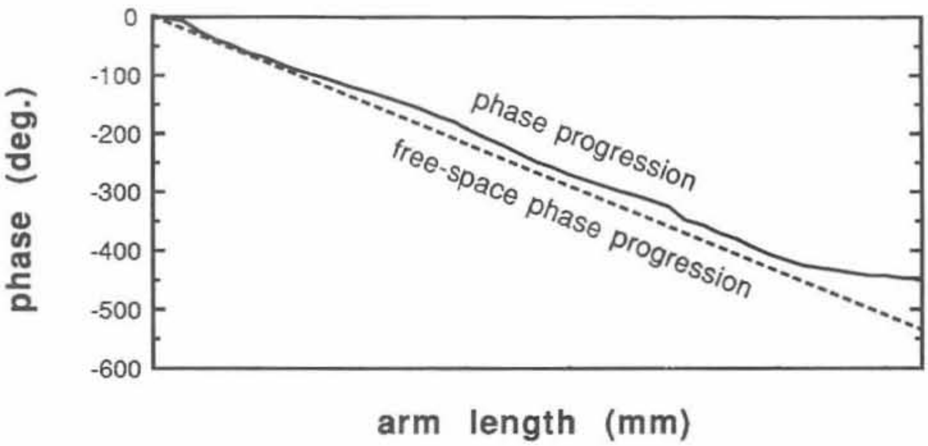

Fig.2 Phase progression of current distribution

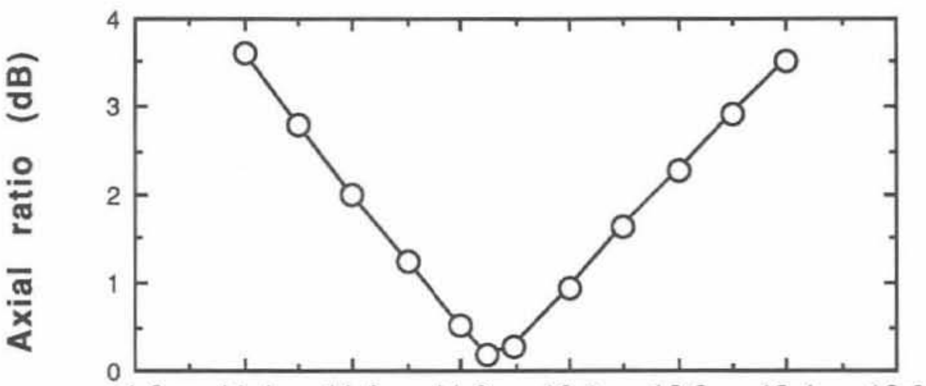

Fig.3 Frequency response of axial ratio

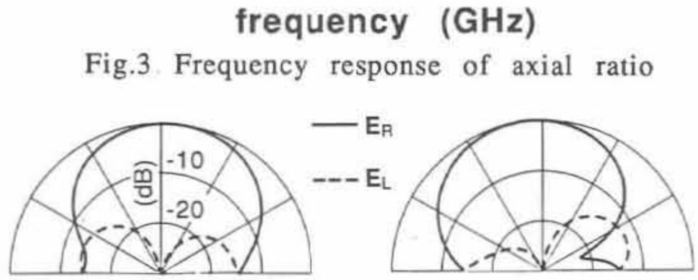

Fig.4 Radiation patterns

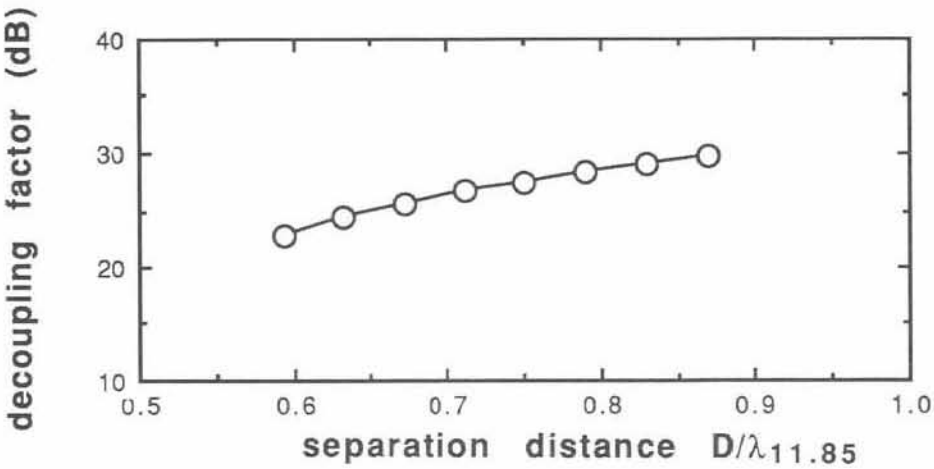

Fig.5 Decoupling factor

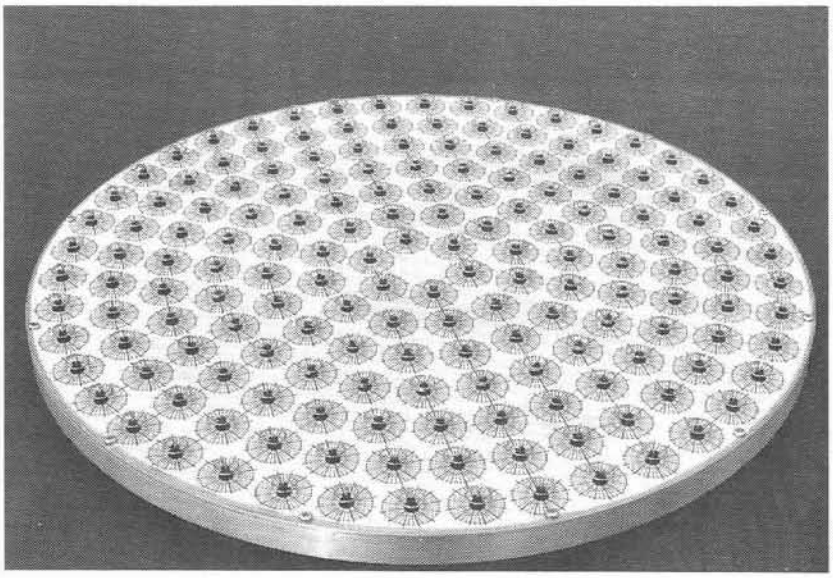

Fig.6 Curl array antenna

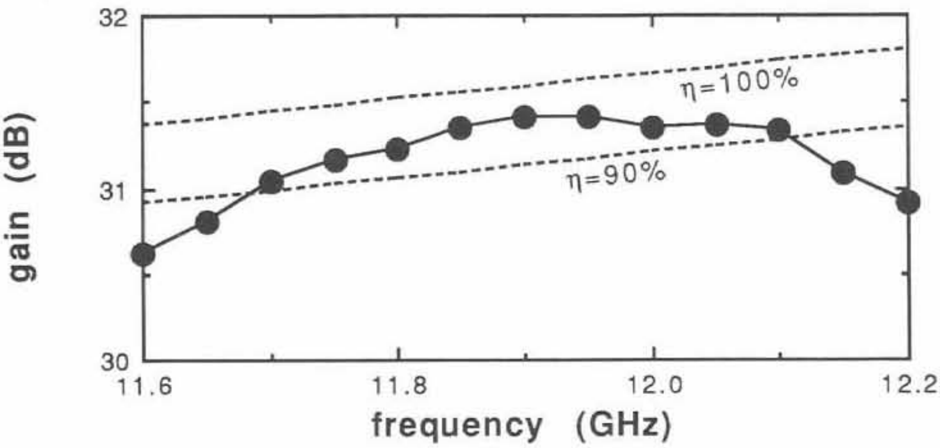

Fig.7 Gain and aperture efficiency