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RADIATION CHARACTERISTICS OF A LOW-PROFILE HELICAL ARRAY ANTENNA WITH A RADOME

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1. INTRODUCTION

It has been shown that a compact low-profile helix can radiate a circularly polarized wave [1]. This helix has been successfully employed in constructing an array antenna for direct reception of broadcasting satellite TV programs (DBS) [2]. In practical applications, such as home reception of DBS, a radome composed of low-loss dielectric materials is required to protect the antenna from adverse enviroments. In general, radomes should not have a significant effect on the electrical performance of the enclosed antenna. However, radomes can have a positive effect on antenna performance, provided the distance between the radome and the antenna surface is appropriately chosen. This principle can be thought of as an extension of the partially reflecting sheet [3]. Recently, a similar approach was used to enhance the gain of microstrip line antennas [4]. Unfortunately, no literature shows the effects of the distance between the radome and the antenna surface on the radiation characteristics of array antennas.

In this paper, we consider the effects of radomes on low-profile helical array antennas. The gain characteristics are experimentally determined over a frequency range of 11.7 GHz to 12.0 GHz. A high aperture efficiency of more than 80% is achieved by a helical array antenna with a properly designed radome.

2. CONFIGURATION

Fig.1 shows the configuration of a low-profile helical array antenna fed from a radial waveguide. The diameter of the waveguide is 397.5 mm and the number of two-turn helical elements is 396. The diameter of the helical cylinder is 8 mm, the wire diameter is 1 mm and the pitch angle is 4°. The arrangement of the helical elements is the same as that reported previously [2]. The insertion length of the feed wire is adjusted to obtain a nearly uniform aperture field distribution.

The radome to be considered here is a circular dielectric sheet with thickness t. Its diameter is the same as that of the array antenna. The spacing between the radome and the waveguide surface is designated as s. We test two materials: vinyl chloride and acrylic resin. The properties of the two materials are summarized in Table 1.

3. EXPERIMENTAL RESULTS

First, we measure the gain characteristic as a function of the spacing s to clarify the effects of the radome. Fig.2 shows the measured gain at

11.85 GHz. The data is expressed as the gain relative to that without the radome. The thickness of the radome is taken to be t=1 mm. It is found that the gain is enhanced by the presence of the radome when the spacing s is 12 mm (approximately half the wavelength). This property is similar to that observed in previous studies [3][4].

Next, we consider the frequency characteristics of the array antenna with the radome. Fig.3 shows the gain of the array antenna as a function of frequency. The spacing s is fixed to be 12 mm. The data for different thicknesses of the two materials are presented, together with data for no radome. The gain at lower operating frequencies is found to increase in the presence of the radome when the thickness is t=1 mm. It is also found that the radome material has little effect on the gain. The aperture efficiency is evaluated to be more than 80% at 11.85 GHz.

Fig.4 shows a representative field pattern for the array antenna with a vinyl chloride radome of thickness t=1 mm. The frequency is taken to be 11.85 GHz. For comparison, the pattern without a radome is also presented. With the addition of the radome, the half-power beamwidth is slightly decreased from 3.7° to 3.6°. A prototype of the helical array antenna with the radome is shown in Fig. 5.

4. CONCLUSIONS

The effects of radomes on the low-profile helical array antenna have been investigated experimentally. The spacing between the radome and the waveguide surface is adjusted to obtain an increased gain. It is found that when a radome consisting of a vinyl chloride sheet has a thickness of 1 mm and a spacing of 12 mm above the waveguide surface, the gain is increased by 0.2 dB, leading to an aperture efficiency of more than 80%.

REFERENCES

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Table 1 Properties of radome materials

Material	Relative permittivity	$\tan\delta$
vinyl chloride	3.3	0.04
acrylic resin	2.5	0.02

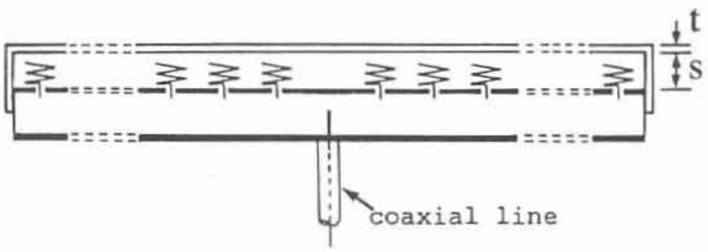

Fig.1 Configuration of low-profile helical array antenna

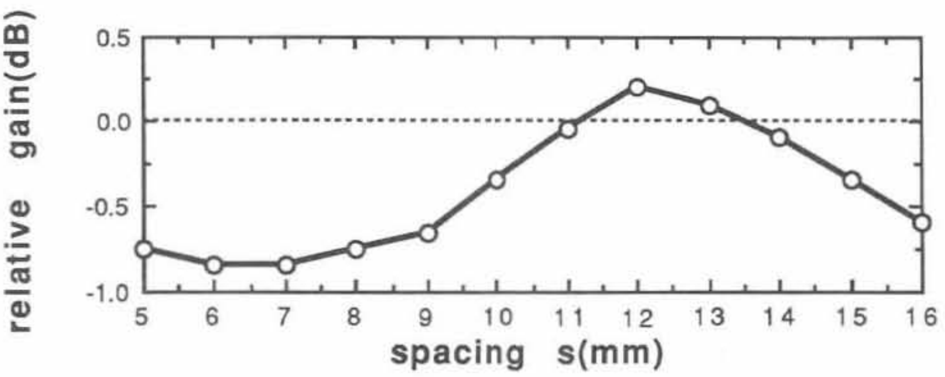

Fig.2 Relative gain as a function of spacing s

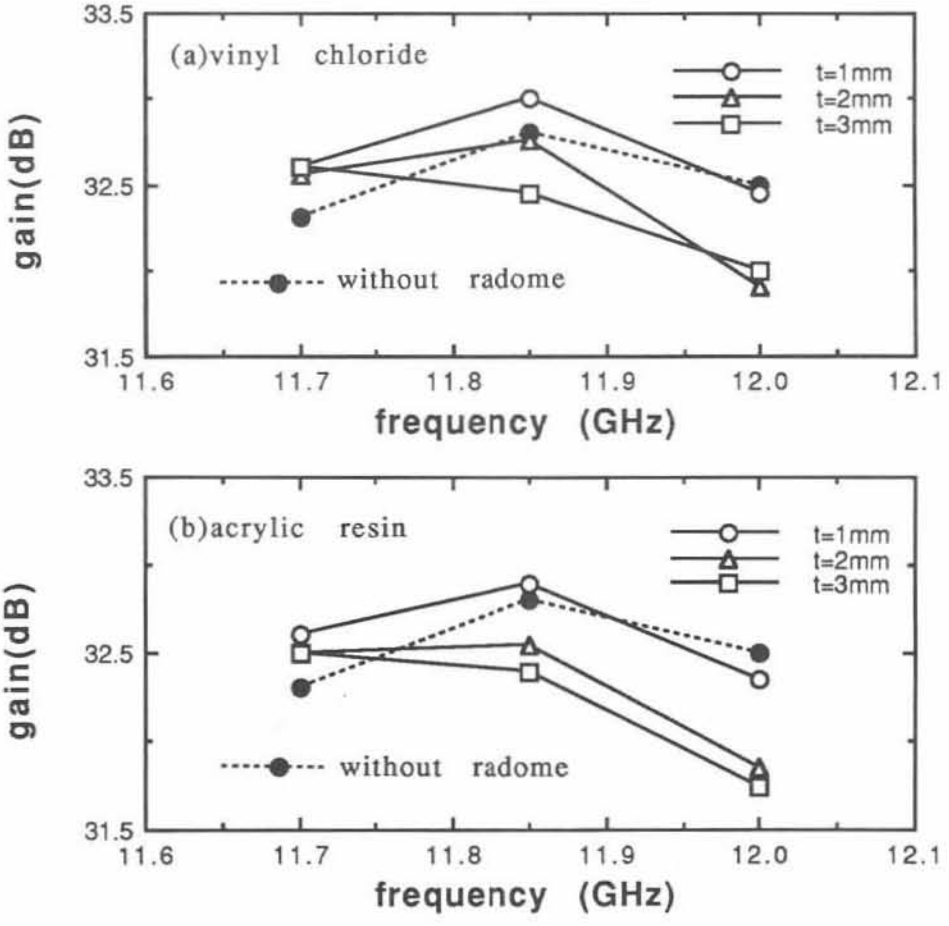

Fig.3 Gain as a function of frequency

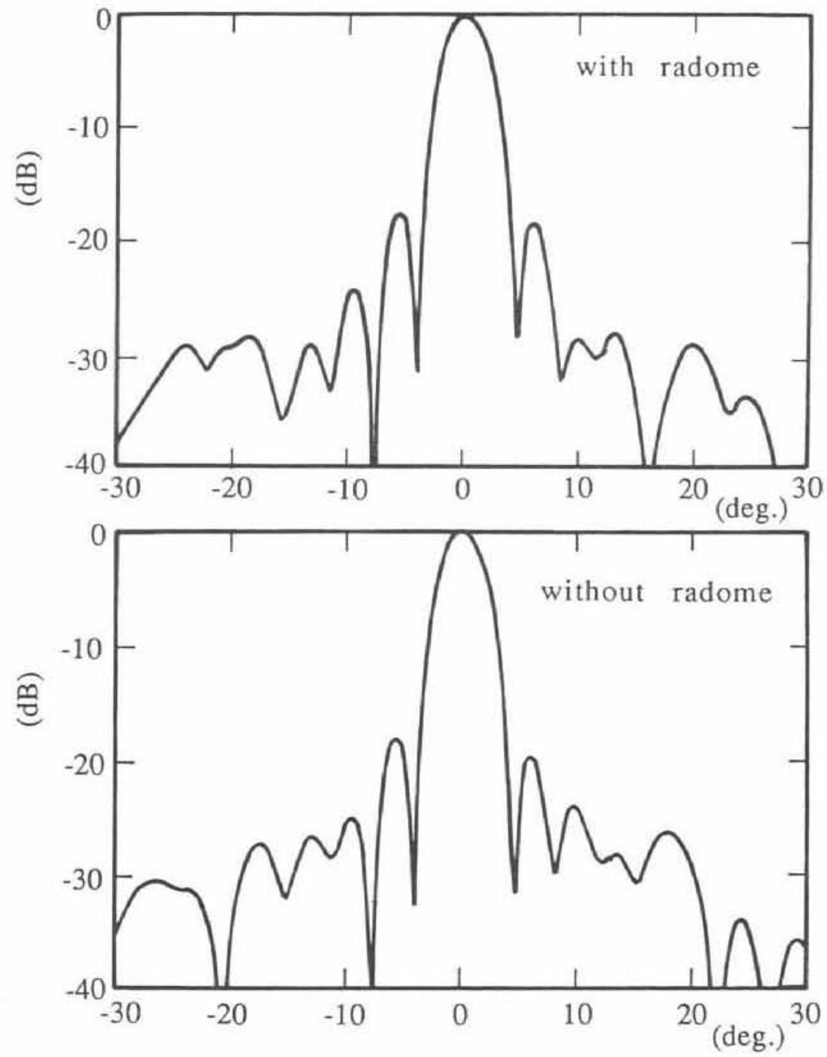

Fig.4 Far-field pattern

Fig.5 A prototype of helical array antenna with radome