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A CAVITY-BACKED CROSSED-SLOT ANTENNA WITH COUPLED MONOPOLES

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1. Introduction

As is well known, it is required for a electronically steered beam array with circular polarization that a low axial ratio and small impedance variation are attained over a beam steering range. The elements suitable for such an array must have low axial ratios over wide pattern angles and their mutual couplings between the elements must be small.

This paper describes the circular polarization properties of a cavity-backed crossed-slot antenna coupled with four parasitic monopoles which is an improved element for use in a circular-polarized array.

2. Theory of Operation

In the conventional cavity-backed crossed-slot antenna, the axial ratio of the circular polarization degrades with increasing angle away from the boresight direction normal to the slot aperture. This is due to the non-uniform angular dependence of the two linearly polarized radiation patterns in the orthogonal planes. In order to improve the nonuniform angular dependence, Clavin et al. [1] proposed the structure which consists of an excited slot with two symmetrically disposed and parasitically excited monopoles. We apply such structure to the cavity-backed crossed-slot antenna.

Fig.1 shows the configuration of the crossed-slot antenna coupled with four parasitic monopoles. When the circular polarization is right-handed, the right and left circularly polarized components in the xz-plane or yz-plane in Fig.1 are given by

$$E_R = \frac{1}{\sqrt{2}} \left\{ (E_{s\theta} + E_{m\theta}) + E_{s\phi} \right\} \qquad (1)$$

$$E_L = \frac{1}{\sqrt{2}} \left\{ (E_{s\theta} + E_{m\theta}) - E_{s\phi} \right\} \qquad (2)$$

where $E_{s\theta}$ and $E_{s\phi}$ are the fields radiated from crossed slots and $E_{m\theta}$ is the field from four monopoles in the xz-plane or yz-plane. In the xz-plane, $E_{s\theta}$ is the E-plane field of the slot 1 and $E_{s\phi}$ is the H-plane field of the slot 2. Two pair of monopoles located on opposite sides of the slot 1 are parasitically excited out of phase with one another. The monopole radiation can be used to cancel the slot 1 radiation in the endfire directions of its E-plane. Such cancellation is not affected by the monopole radiation excited by the slot 2. By properly adjusting the monopole height and spacing, the θ component can be made to closely approximate the ϕ component over a wide angular range. Thus, E_L approaches zero from (2) and good circular polarization can be realized over a wide angular range. In the yz-plane, the operation is the same as that in the xz-plane.

3. Measured Results

In order to test the operation presented in the previous section, an L-band antenna model was made (Fig.2). The crossed slots are backed by a shallow cavity which is 0.48 λ square and 0.05 λ deep, and the antenna is mounted on a 5.3 λ square ground plane. In order to obtain a symmetrical radiation pattern, each slot is symmetrically fed from the slot ends by means of coaxial lines as shown in Fig.3. The necessary phase of quadrature feed for circular polarization is provided by a 90° hybrid. Fig.4 shows measured and calculated axial ratios in the xz-plane, where h is 0.37 λ and d is 0.05 λ. Measured axial ratios are below 2 dB over an angular range of 120°. Wide-angle axial ratios are much improved as compared with those of the conventional crossed-slot antenna. Measured values agree well with the calculated result for $-45° \leq \theta \leq 45°$. In the calculation, we assumed that the electric fields in the two slot apertures had simple cosinusoidal distribution and the currents on the four monopoles had single sinusoidal distribution [2]. The phase error of the excitation of the two crossed slots was included in the calculation.

Fig.5 shows the right circularly polarized radiation pattern in the xz-plane. The 3 dB beamwidth is about 78°. The cross-polarized component is below -20 dB over a angular range of about 120°. It is found that good circular polarization is obtained over the wide angular range.

The measured voltage coupling coefficient [3] between the improved elements 0.52 λ apart is -21 dB. The coupling coefficient is very small in comparison with that of the conventional crossed-slot antenna [4].

4. Conclusion

The cavity-backed crossed-slot antenna coupled with four parasitic monopoles has useful properties as an improved element for use in a circular-polarized array.

Acknowledgement

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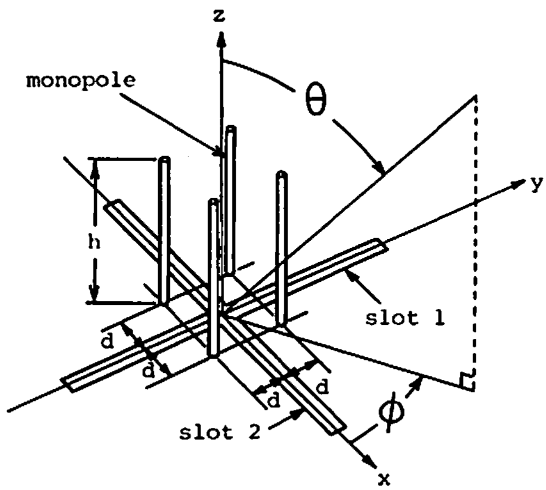


Fig.1. Configuration of antenna.

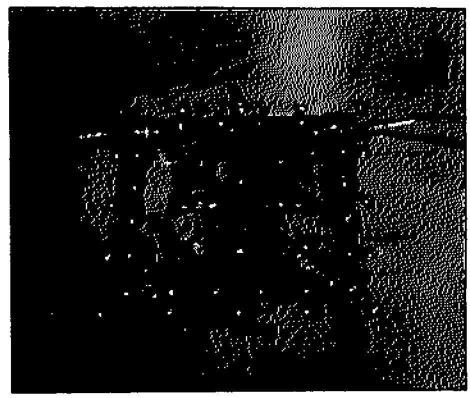


Fig.2. Experimental antenna model.

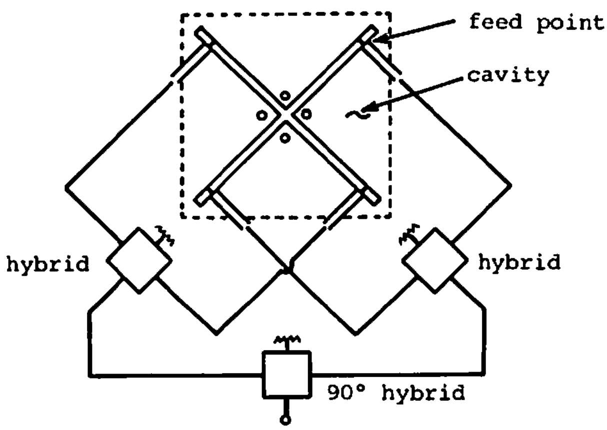
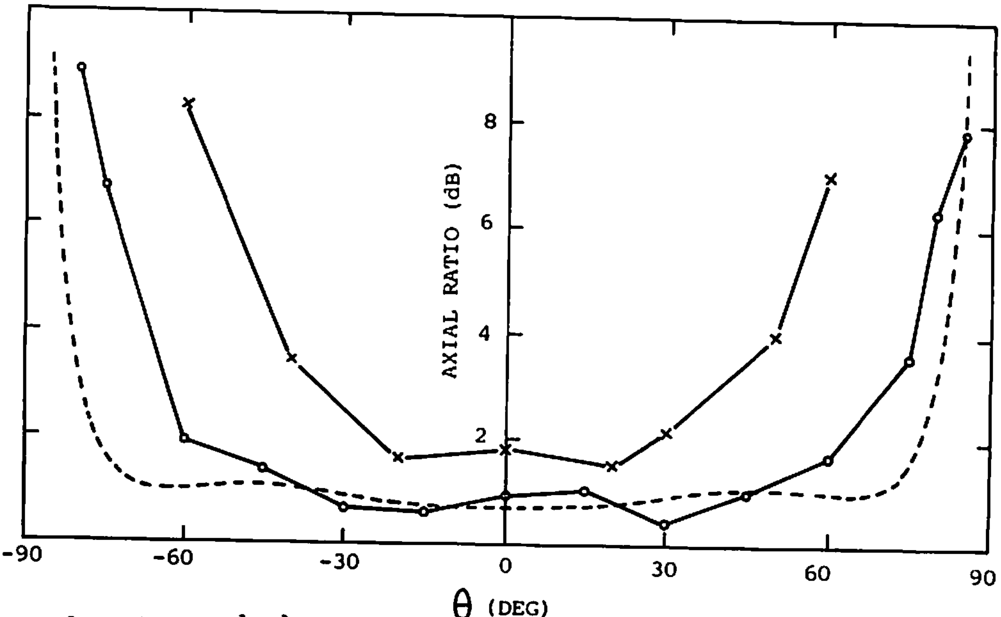


Fig.3. Feed network for circular polarization.



—o— measured
---- calculated } h=0.37λ , d=0.05λ
—x— measured without monopoles

Fig.4. Axial ratios.

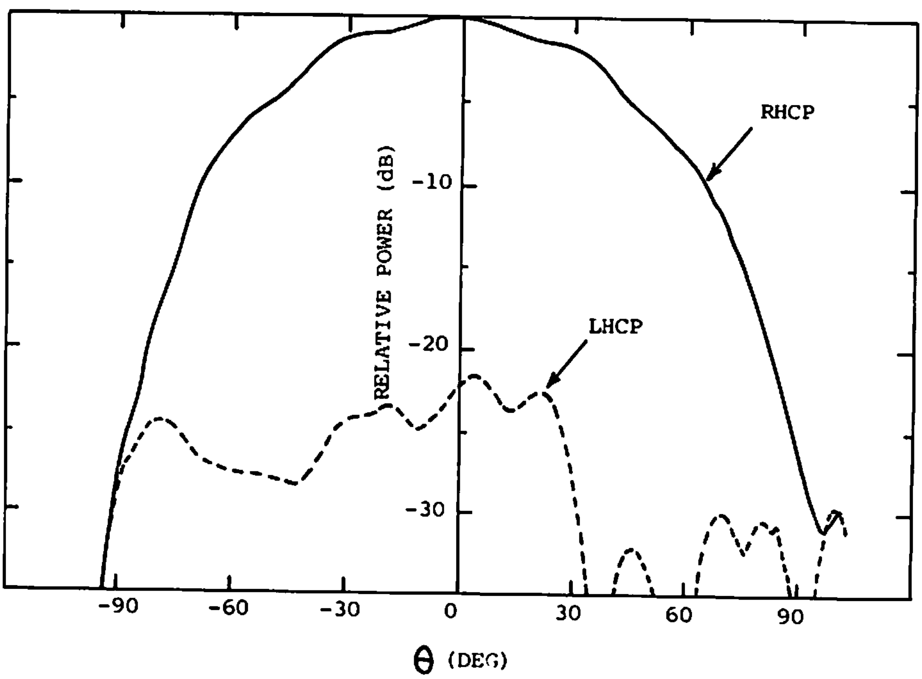


Fig.5. Radiation patterns.