A WIDE BANDWIDTH LOW SIDELOBE LOW PROFILE MICROSTRIP ARRAY ANTENNA FOR COMMUNICATION APPLICATIONS

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Introduction

Flat plate array antennas are an attractive alternative to established reflector antenna designs in a wide range of communication applications provided acceptable electrical performance can be achieved and manufacturing costs can be kept low. The design and testing of a linearly polarised flat plate array antenna consisting of 1280 rectangular microstrip patches is presented. For this study the major design objectives were:

- (i) 10% operating bandwidth;
- (ii) low sidelobe performance in the horizontal major plane;
- (iii) crosspolar isolation better than -25dB on boresight;
- (iv) compatibility with printed circuit board manufacturing techniques.

Design for wide bandwidth

Microstrip patch radiators are known to have small bandwidths, typically around 2.5%. Established methods of improving element bandwidth include the use of thick substrates [1], the use of parasitically excited patches [2], and aperture feeding from a microstripline behind the patch ground plane [3].

For large arrays cost constraints and unacceptable mutual coupling between fed elements prohibit the first method and so a combination of the other two methods was employed [4]. The array element shown in Figure 1, consists of a sub-array of five identical rectangular microstrip patches in a cross configuration. The sub-array is excited from a non-resonant aperture in the ground plane positioned under the centre element which in turn is excited by a microstripline on a second substrate. This array element provides a 10dB return loss bandwidth of 10.5%.

Layout and size considerations

A prototype array consisted of 256 of the sub-arrays in a 16 by 16 lattice.

The disadvantage of the five-patch-cross element is that its length and width are too great to allow a rectangular array to be constructed which is free from grating lobes in the far field. A triangular layout is possible however, which does allow this. Figure 2 shows a drawing of the test model antenna showing array elements and layout.

A corporate r.f. power combiner was chosen, which since each sub-array requires only one feed is a 256:1 port network.

Design for low sidelobes

Low sidelobe performance in one major plane is designed for by using a one-dimensional aperture taper, obtained by using unequal coupling values in the binary power splitters used in the corporate combiner, combined with the directivity of the sub-array. Starting with a target copolar radiation pattern envelope an in-house radiation pattern analysis package was used to optimise the sub-array excitations.

To simplify design of the corporate feed network, a further program was developed to minimise the number of discrete microstrip power splitters in the network. The 256:1 design achieved the required taper using only four different splitter designs.

Construction

The antenna is constructed from two 0.506mm PTFE based substrates each with a dielectric permittivity of 2.2. Each of the substrate boards has patterns etched on both surfaces. The first substrate board has the array elements printed on one side and a copper ground plane with oversized apertures on the reverse side. The oversized apertures play no part in the electrical performance of the antenna but aid in the manufacture during the bonding process. The second substrate board has the non-resonant precision coupling apertures on one side and the power combining network on the other side. The two substrate layers are aligned and bonded together under pressure using a proprietary printed circuit board (PCB) low temperature bonding material. The precision coupling apertures register with the oversized apertures and locate accurately under the driven patch elements.

Prototype array performance

Some initial measured results for the prototype array are summarised below. The measured 10dB return loss at the input port is 11%. Figure 3 compares measured and predicted H-plane copolar radiation patterns. It is apparent that while the main beamwidth is in agreement with the prediction, the measured sidelobe level is rather high with a peak level 21 dB down. This is possibly due to: scattering from the substrate edge or the array mounting structure; difficulties in keeping the array physically flat; mutual coupling between elements. Further measurements are required to establish the exact cause. The measured directivity is estimated by pattern integration to be 32dBi, which compares with a predicted value of 33.9 dBi. The measured gain at the input port is 28 dBi, which implies a feed network loss of about 4 dB. The boresight crosspolar level is -39dB down on boresight copolar level with peaks at -30 dB, 6 degrees off boresight.

Conclusions

A flat plate microstrip array antenna compatible with PCB manufacturing techniques has been demonstrated. The antenna has a 10dB return loss bandwidth of 11% and a measured gain of 28 dBi. The peak crosspolar level was 30dB down with the peak sidelobe level 21dB down. Future work will involve improving the gain and sidelobe performance of the array antenna.

References

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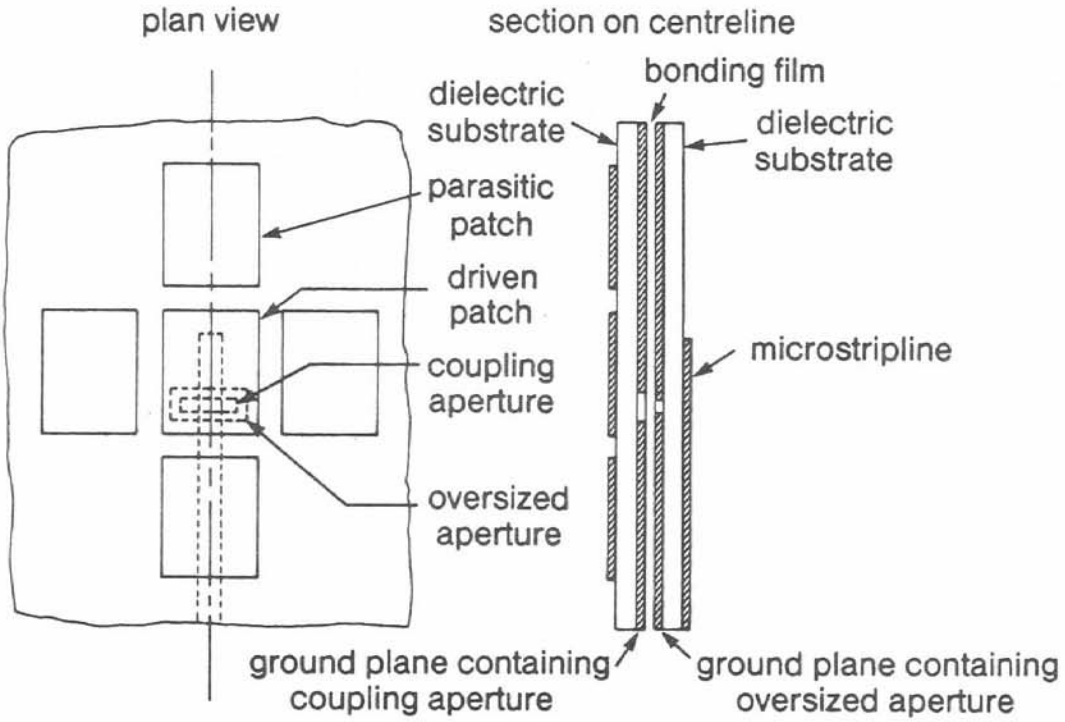

Figure 1. Array antenna element showing feed mechanism and construction

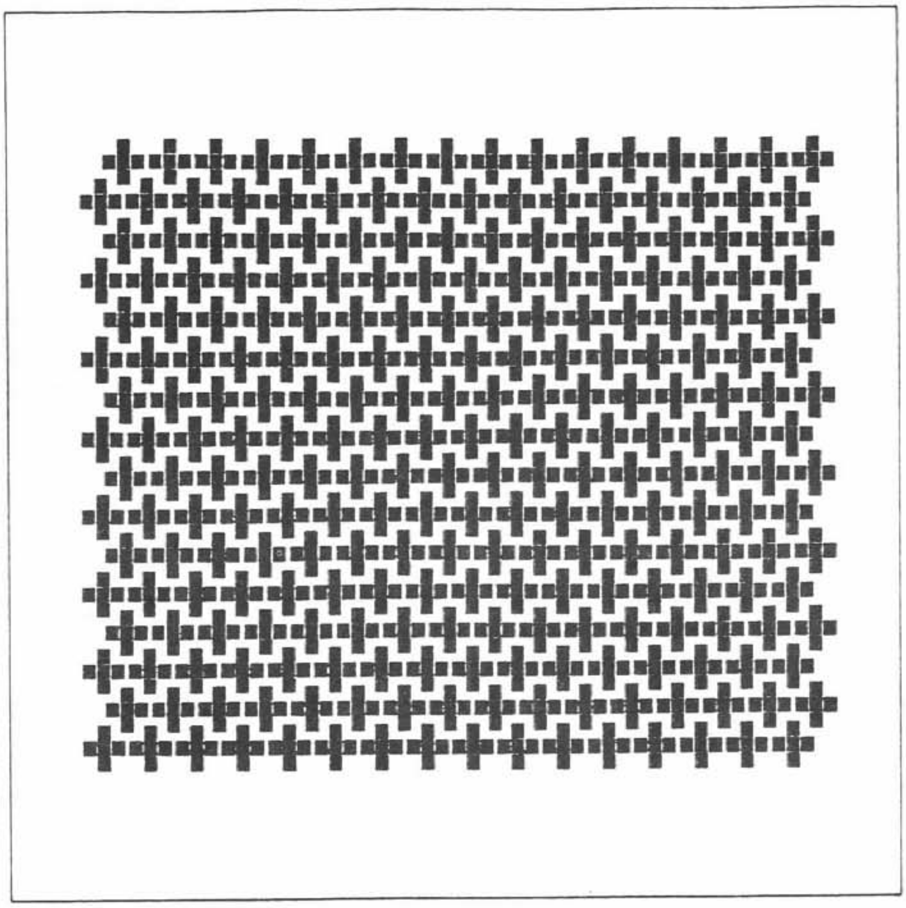

Figure 2. Drawing of array antenna radiator level showing the 1280 patches

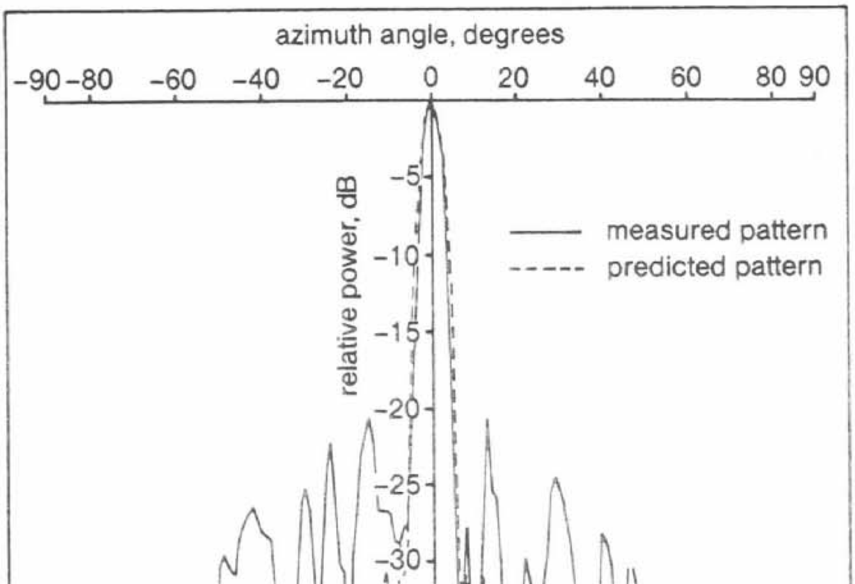

Figure 3. Measured and predicted H-plane radiation patterns of array antenna