A PLANAR ANTENNA COMPOSED OF STRIP DIPOLES AND SLOTS AND ITS APPLICATION TO DBS RECEPTION

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1. INTRODUCTION

Many types of printed array antennas have been studied and developed for receiving DBS (direct broadcasting from a satellite) [1]. DBS system requires a circularly polarized antenna with high gain and good axial ratio. CP-PASS (Circularly Polarized Printed Array composed of Strip dipoles and Slots) is a type of series-fed arrays which is lower in loss of feed network compared with corporate-fed arrays. The basic element of the array consists of a strip dipole in a window and a slot which are fed in series by a microstrip line. The window is placed in the ground plane in order to increase effectively the gain and bandwidth of the strip dipole. CP-PASS has been designed and fabricated mainly at 3GHz, and good performance was reported [2].

In this paper, a configuration of a planar array is discussed in order to develop a high gain CP-PASS, and verified by experiments. First, its feed network is discussed and tested. Secondly, a planar subarray is fabricated and measured, and finally, a CP-PASS composed of 320 element-sets is designed and, measured.

2. CENTER-FEED NETWORK

When a CP-PASS is designed as a linear-type array, its radiating elements are placed at left and right sides of a microstrip line, so that unwanted radiations from the windows can be effectively suppressed. However, if a planar array is formed with the same arrangement, more complicated design would be needed because of strong coupling effects between the elements on adjacent feed lines. Therefore, one-sided strip elements should be used without depolarization.

For example, at 3GHz, a bent microstrip line was adopted and some sets of radiating elements were arranged along the line [2].

At 12GHz, however, this configuration would not be realizable. Because the bent microstrip lines would be overlapped each other if the subarrays were arranged with equal elements spacing.

So as to overcome this, the microstrip line was fed by a tee-junction from its center and the elements were placed one side of the line [3]. An example of this center-feed subarray is shown in Figure 1, which also indicates the coordinate system.

To verify the effect of center-feed, two different types of CP-PASS without slots were fabricated. One was a planar array composed of 10×2 elements using center-feed microstrip lines, the other was a linear array composed of 5 elements. Figure 2 shows the experimental results. Because of center-feed, the unwanted cross polar radiation could be well suppressed over wide frequency ranges.

3. SUBARRAY COMPOSED OF 40 ELEMENT-SETS

As a component of a planar subarray, a linear-type CP-PASS with 5 elements was designed according to the same procedure for 3GHz array [2]. The antenna was constructed on both sides of a conventional glass cloth reinforced PTFE substrate having a thickness of 0.8 mm and a dissipation factor of 0.0019 at X-band with a dielectric constant of 2.55. As mentioned in the preceding section, the subarray comprises the linear arrays and the tee-junction feed networks on the same substrate. Figure 3 shows the back and front views of this subarray.

A reflector, sized $0.15 \times 0.20\ m^2$, was placed under the ground plane at a distance of a quarter wavelength, and maximum co-polar actual gain of 22.0 dBi was obtained. Figure 4 shows the measured radiation pattern of $|E\phi|$ component in the yz-plane at 12.0 GHz. The outline of this curve resembles a function of sin(x)/x except for its symmetry.

It can be said that the first sidelobe level of about -14 dB in Figure 4 is the result from the transmission loss of the microstrip feed line. Figure 5 shows the calculated first sidelobe levels for a array consists of point sources located at the same position of the strip elements of the present array. This indicates that the loss of the line was about 10 dB/m in effective. Therefore, higher actual gain will be obtained in this array, if a low loss substrate is employed.

4. CP-PASS COMPOSED OF 320 ELEMENT-SETS

As a trial piece of high gain CP-PASS, a 320 element-sets array consisting of 16 subarrays (10×2 element-sets) was designed and fabricated. Figure 6 shows a view of the antenna. A 16-way power divider using microstrip line tee-junctions was installed backside of a reflector and connected with each subarray using semi-rigid coaxial cables. The antenna had a size of about $0.28 \times 0.35\ m^2$.

Figure 7 shows the radiation pattern of the co-polar component measured at 12.0 GHz in the yz-plane. The half-power beamwidths in the yz- and xy- planes are 4.1° and 5.3° ,respectively. The side lobe level is about -8 dB in the yz-plane and about -13 dB in the xy-plane. The side lobe level in the yz-plane may be reduced by improving the fabrication error.

Figure 8 shows the measured co-polar actual gain versus frequency. A maximum co-polar gain of 29.0 dBi or a aperture efficiency of 43 percent was obtained. A 3 dB bandwidth was more than 1GHz.

By using this CP-PASS array, the broadcasting program from a Japanese DBS could be received with good stability.

5. CONCLUSION

A configuration of a subarray for planar-type high gain CP-PASS at 12GHz has been discussed and tested in practice. In the planar-type CP-PASS composed of 320 element-sets, the maximum actual gain of 29.0 dBi and the bandwidth of over 1 GHz were obtained. The possibility of applying CP-PASS to the high gain antenna for DBS reception has been verified.

REFERENCES

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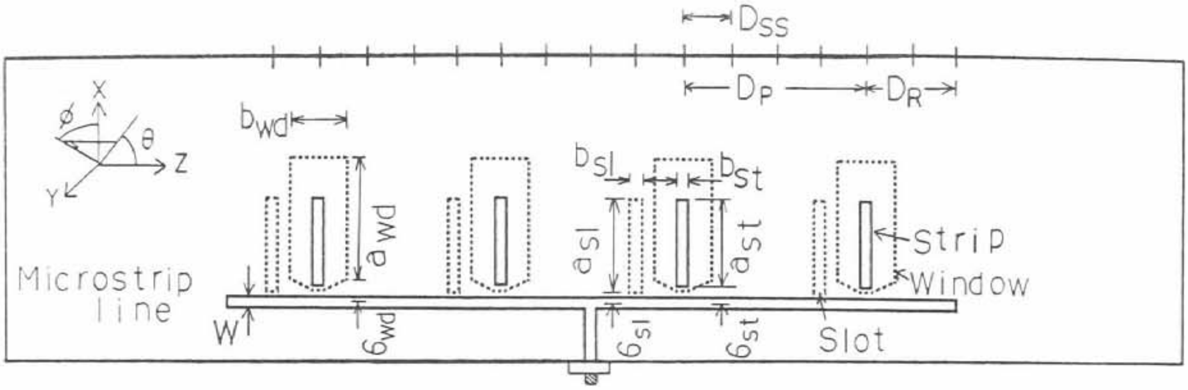

Fig. 1 Configuration of center feed CP-PASS (M=4 sets) and co-ordinate system.

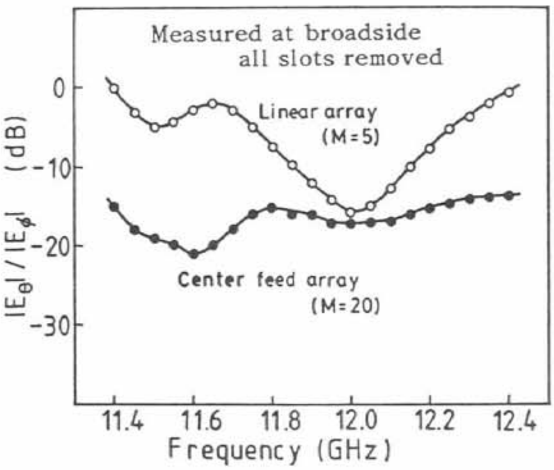

Fig. 2 Measured crosspolar suppress ratio vs frequency.

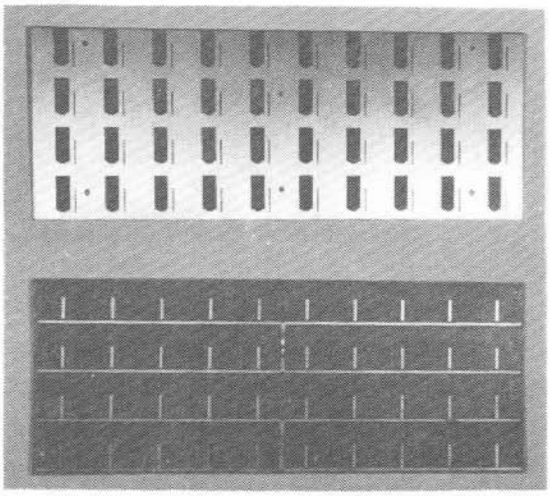

Fig. 3 Back view (upper) and front view (lower) of planar subarray.

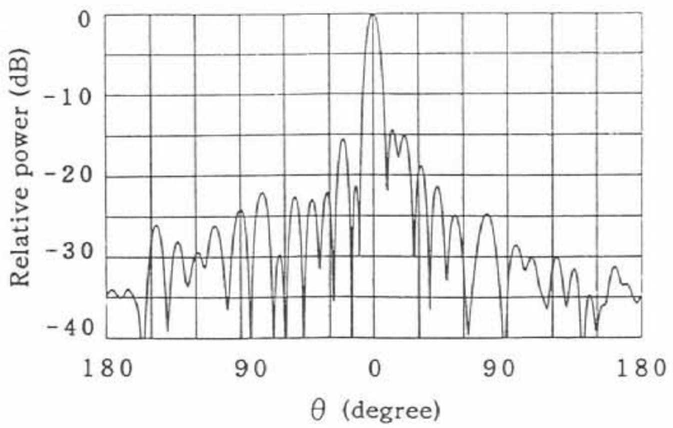

Fig. 4 Measured radiation pattern in yz-plane at 12GHz for CP-PASS composed of 40 element-sets.

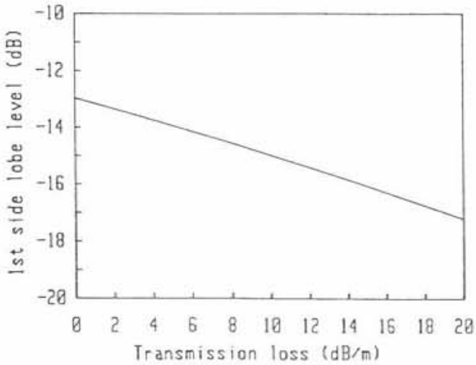

Fig. 5 Calculated first sidelobe levels for antenna shown in figure 3 vs transmission loss of MS-line.

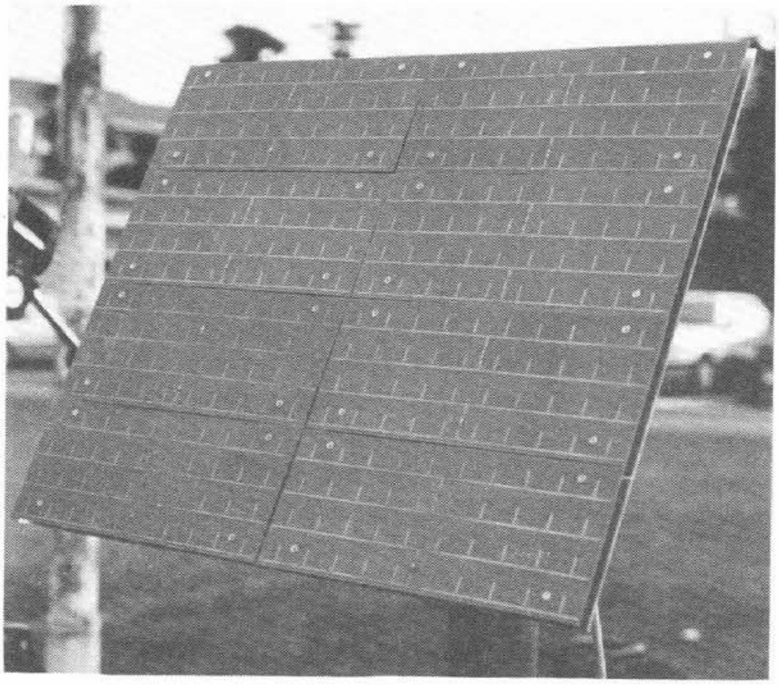

FIg. 6 View of CP-PASS composed of 320 element-sets.

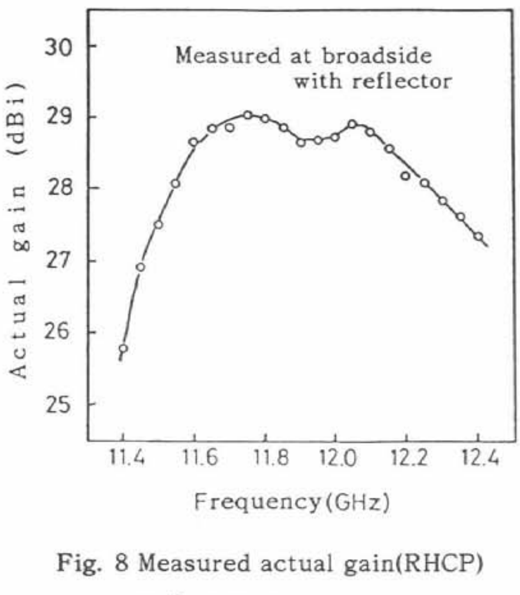

Fig. 8 Measured actual gain(RHCP) vs frequency.

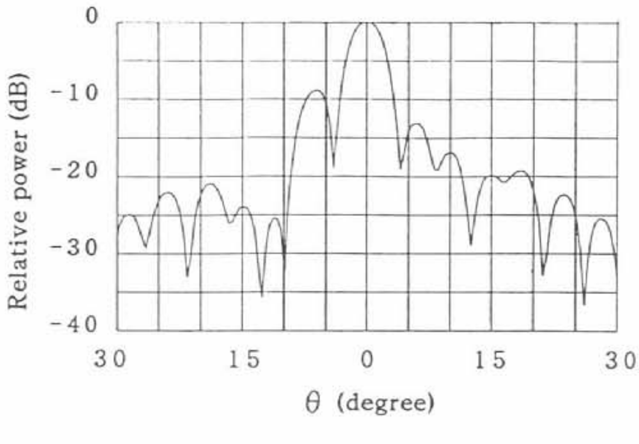

Fig. 7 Measured radiation pattern in yz-plane at 12GHz for antenna shown in Figure 6.