A 12 GHZ BEAM-TILT TYPE PLANAR ANTENNA

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ABSTRACT

A Ku-band Planar array of 32x32 elements is presented. A new method of making a phase difference between the adjacent circularly polarized annular slots is discussed to produce a beamtilt angle of 23 °. Measured antenna gain and efficiency were 34.5 dBi and 50 % respectively.

INTRODUCTION

In the Broadcasting Satellite receiving technology, planar antennas have advantages for increased facilities of installation and protection of the antenna against storm and snow. To cover most part of Japan, a typical BS receiving antenna requires a converter with noise figure of 1.4 dB and the minimum antenna gain of 34.5 dBi.

A beam tilt angle of 20 ° - 30 ° may be a good trade-off between a reduction of the lateral dimensions and an improvement of the efficiency, which depends on the projected area of the antenna (1),(2).

Reducing size and increasing bandwidth are also important problems of the planar antenna.

Collier (3) has reported a wide-slot antenna coupled by a single stripline, which showed a dominant characteristics of wide bandwidth. Bahl (4) also reported a promising characteristics of the annular slot antenna. The annular slot radiator can be operated in the circular polarization mode by some modifications.

In the process of designing the antenna, the following points were considered and achieved: (1) high efficiency with beamtilt, (2) uniform excitation of radiators, and (3) wide axial ratio bandwidth.

ANTENNA DESIGN AND EXPERIMENTS

Fig. 1 shows the dependence of the planar antenna gain on the feeder loss comparing gains of parabola antennas with an efficiency of 60 %. Maximum permissible feeder loss may be 3 dB/m for a planar antenna of 50 % efficiency.

For a preliminary test, characteristics of a prototype microstrip planar antenna (2) have been measured using various substrates. Losses of some micorstrip lines were as low as 2db/m in an arrangement of straight line. However, they produced only a little improvement upon the performance of the actual feeder network that consists of many divider tees and bends, which resulted in a random RF power radiation.

A combination of triplate strip line and segmented annular slot radiator was chosen for this purpose as a result of some experiments. Both the elements are shaped on the shin films and are spaced on the ground plain using the substrate of foamed polyethylene (εr=1.2).

Circular polarization is possible from an annular slot if we give a phase difference of 90 ° between the two orthogonal modes of the antenna. A well known method of perturbation segments was applied for the experimental determination of the radiator element.

We investigated the characteristics of a unit array consists of four square slot elements for calculations purpose. Fig.2 shows the curves of efficiency and gain of the unit array plotted as a function of the normalized spacing of the elements. They have maximums at 0.8 and 0.85 respectively.

Suppressing the grating lobes of the antenna, vertical and horizontal normalized spacings have decided to be 0.64 and 0.8.

Fig.3 shows a new type of arrangement of the array as a result of these considerations. A phase difference of 90 ° between the adjacent elements is made by a 90 ° rotation of the circularly polarized radiators that is driven by the feeders of equal length from a divider. The beam-tilt angle θ made by the rotation angle α is expressed by the following equation.

$$\sin\theta = \alpha\lambda_0/(2\pi d)$$

Fig. 4 shows calculated patterns when the element spacing is varied. An example of the optimum performance is shown in Fig. 4 (b).

This method can simplify the feeder network arrangement and it has several merits: (1) feeder lengths are minimized; (2) parasitic couplings between the elements are reduced; (3) an apparent axial ratio of the array is improved; and (4) variations of phase shift between the adjacent radiators or variation of beam tilt with the operating frequency are reduced.

All the antenna couplers are combined to the single feeder line through the network in which characteristic impedance ranges 70 120 ohms. Fig. 5 shows measured far field radiation patterns of the beam-tilt type planar antenna at 11.85 GHz. These patterns agreed fairly well to the calculated ones. Small grating lobes appeared in the vertical plain, which are greater than calculated ones, may be due to non-uniformity of the array excitation.

Power gains of the antenna are plotted as a function of frequency in Fig. 6. Minimum gain of 34.5 dBi is obtained over the SHF TV band of 300 MHz centered at 11.85 GHz. Aperture efficiency of 50 % is derived from the effective antenna area of 640 x 512 mm.

Measured axial ratio of the antenna was within 1dB and was flat through the band.

CONCLUSION

A beam-tilt type planar antenna for SHF TV reception is considered to have reached the stage for practical use. A new array technique has proved its remarkable effect to a particular antenna design.

ACKNOWLEDGMENT

The authors wish to thank Dr. A. Takahashi for his helpful advice.

REFERENCES

(1) M.Haneishi, S. Saito, Y.seshimo, A. Kaise, "Beamtilted Circularly Polarized Planar Antenna for DBS-Reception,"ITEJ Technical Report Vol.10,No.44,pp.16, RE '871(Jan.1987)

(2) M.Haneishi, S. Saito, A. Kaise, "A Beamtilted Planar Antenna for DBS," RE8831,Vol. 12, 35 (1988-9)

(3) M. Collier, "Microstrip Antenna Array for 12 GHz TV,"Microwave J., Vol.20,Sept.1977,pp.67-71.

(4) I.J.Bahl and P.Bhartia,MICROSTRIP ANTENNAS, pp.221246,Artech House, 1980

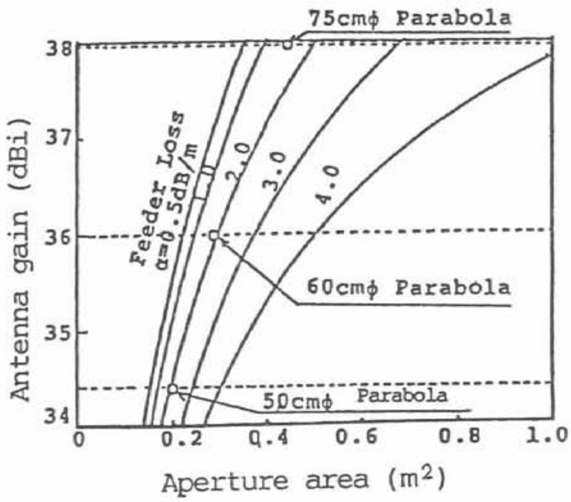


Fig. 1. Gain of planar antenna with feeder loss

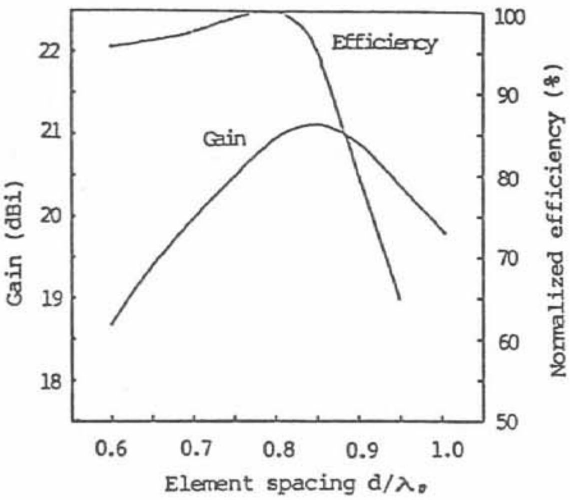


Fig. 2. Normalized efficiency and antenna gain vs. spacing

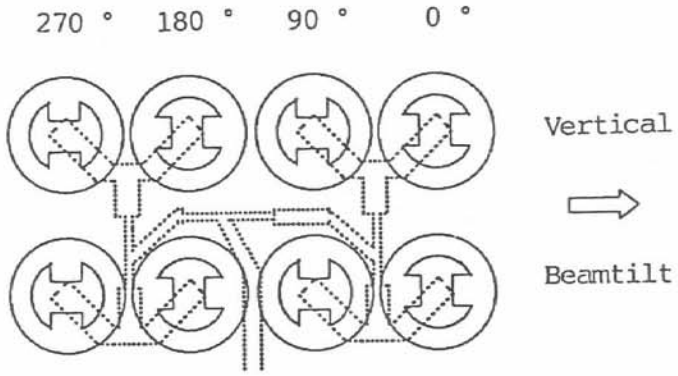
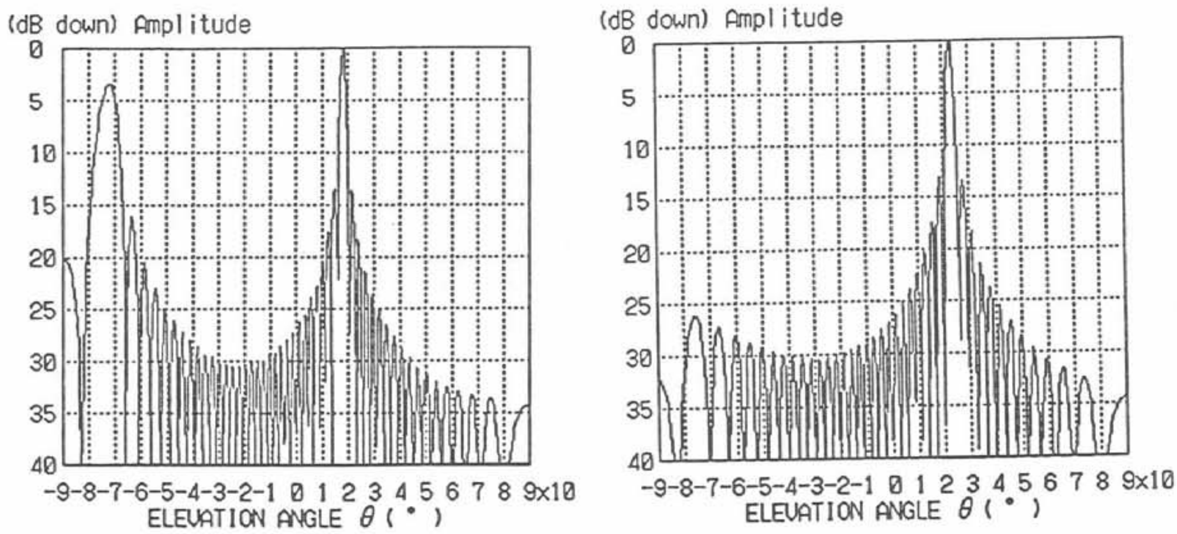


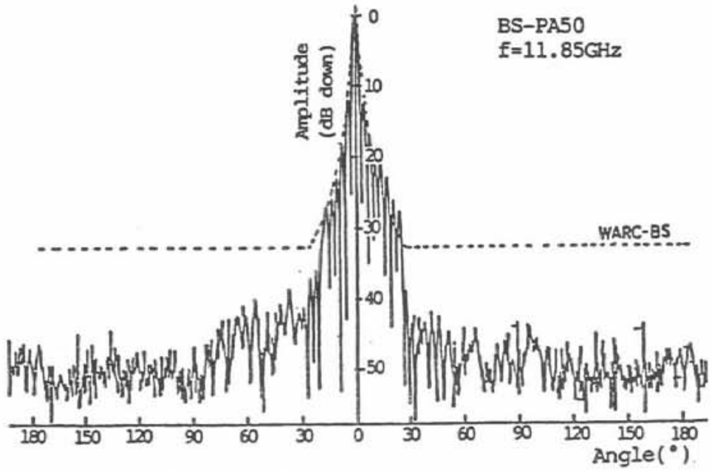
Fig. 3. Unit array arrangement for beam-tilt



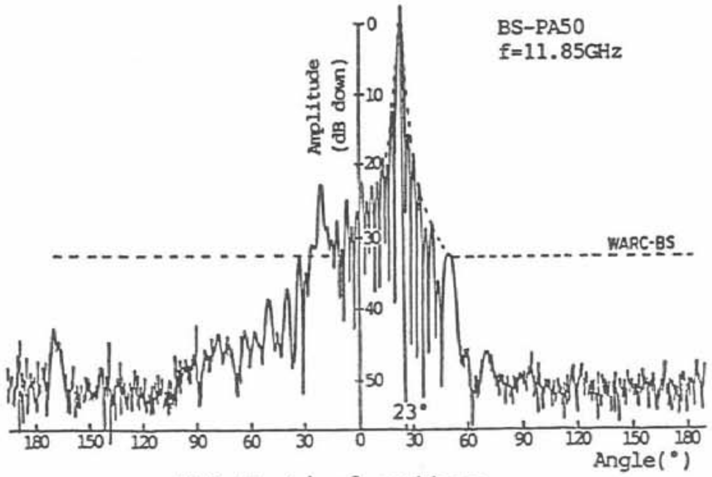
(a) d/λ_0=0.8, θ_t=18.2 °

(b) d/λ_0=0.64, θ_t=23 °

Fig. 4. Calculated patterns in the tilt plane



(a) Horizontal pattern



(b) Vertical pattern

Fig. 5. Radiation pattern of a 32x32 array measured by spinning dipole

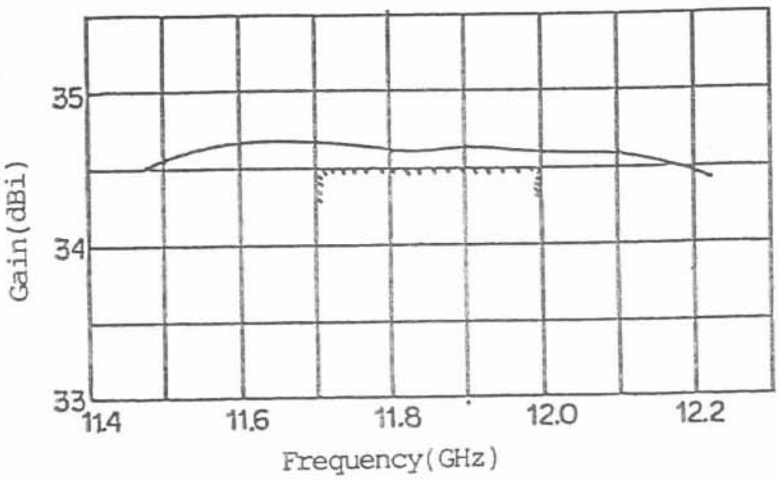


Fig. 6. Measured gain of a new type of planar antenna