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LOW SIDE-LOBE CIRCULARLY-POLARIZED SHAPED-BEAM ANTENNA FOR SATELLITE USE

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Introduction

The communication antenna installed on a spacecraft located in a geostationary orbit is desired to have an effective radiation pattern to the desired area and to have low sidelobe level to decrease radio interference.[1) 2)]

This paper describes the experimental results of a shaped-beam antenna with an offset parabolic reflector fed with circular polarization.

The purpose of the experiments is to investigate the capability of synthesizing the circularly-polarized shaped-beam pattern and reducing sidelobe level.

To synthesize the shaped-beam pattern, a multi-feed horn which radiates a multi-beam is used.[3)] Each feed horn is fed by appropriate feed conditions.

The offset parabolic reflector can reduce the sidelobe level because there is no feed horn blocking. The feed system consists of power dividers and phase shifters. Each feed horn has linear polarization.

A parallel metal plate polarizer is located in front of the multi-feed horn.

Antenna Configuration

The parabolic reflector used in experiments is elliptical in shape. Focal length is 85 cm. Major and minor axis lengths of the parabolic reflector are 159 cm and 103 cm, respectively. Experiments were accomplished in the K-band.

The antenna system is designed to effectively radiate a composite radiation pattern to the Japanese islands by three horns.

Three feed horns are fed at a power ratio of 0.8:0.08:0.12 by power dividers. Phase is adjusted in phase by phase shifters.

Feed horn aperture sizes are designed after some considerations on beam separation and beam efficiency. The feed horn, which feeds maximum power, is placed on the focal point of the parabolic reflector.

The multi-feed horn is inclined at an angle of 34 degrees to a line which connects the focal point with the vertex of the parabolic plane of the reflector.

The circular polarizer is designed at 12 GHz and is rectangular planar with 15 x 30 cm in size. The distance between the polarizer and multi-feed horn is about 6 cm. The complete antenna system is shown in Fig. 1.

Experimental results

Figure 2 shows the circularly-polarized radiation pattern in the plane of the major axis of the parabolic reflector at 12 GHz.

The sidelobe level can be reduced to less than -30 dB.

Figures 3-a and 3-b show the contour lines of the antenna gain which are drawn on a map of the Japanese islands.

Figures 3-a and 3-b are composed from measured radiation patterns with linearly-polarized (without circular polarizer) and circularly-polarized antenna (with circular polarizer).

The location of the spacecraft is assumed in a geostationary orbit at 110°E.

Figure 3-b indicates that the circularly-polarized shaped-beam antenna can be realized by the simple method with a parallel metal plate polarizer.

These patterns satisfy the coverage to transmit 28 dB antenna gain RF signals to the Japanese islands. However there are several differences between linearly- and circularly-polarized radiation patterns.

The beamwidth of the circularly-polarized pattern is a little wider than that of linearly-polarized pattern and there is a little reduction in peak gain for the circulary-polarized antenna.

One of reasons for these differences is the effect that an incident wave, which comes at an oblique angle with respect to the plane of the metal plate, is blocked by the metal plate. The blocking at the metal plate makes some changes in the electromagnetic field distribution on the parabolic reflector. The cross polarization level is -20 dB within the mainbeam at 12 GHz.

Conclusion

The capability of synthesizing a circularly-polarized shaped-beam pattern was investigated by the simple method of using a parallel metal plate polarizer.

The experimental results indicate the feasibility of realizing a shaped-beam pattern with circular polarization.

An antenna with an offset parabolic reflector can reduce the sidelobe level enough to decrease radio interference. The circular-polarizer with low cross-polarization in the wide frequency band will be desired for synthesizing of wide-band shaped-beam pattern.

References

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(2) Y. Mikuni, T. Morooka et al., "Antennas of Medium-Scale Broadcasting Satellite for Experimental Purpose", Toshiba Review, No.100, 1975.

(3) S. Silver: "Microwave antenna theory and design", MIT Radiation Lab., McGraw Hill, 1949.

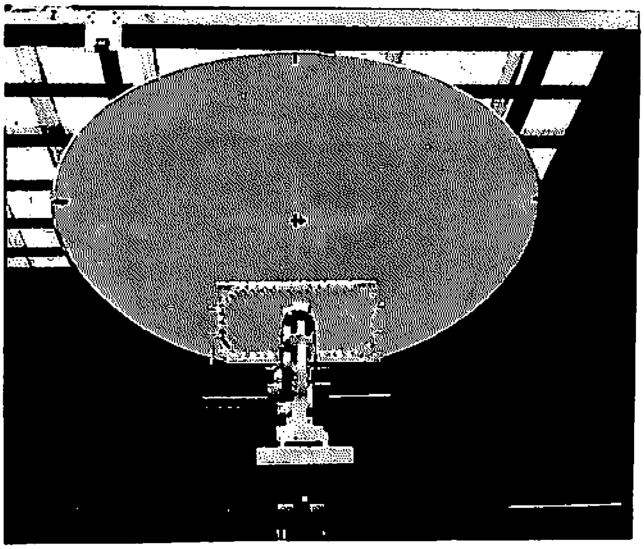

Fig. 1 Antenna Configuration

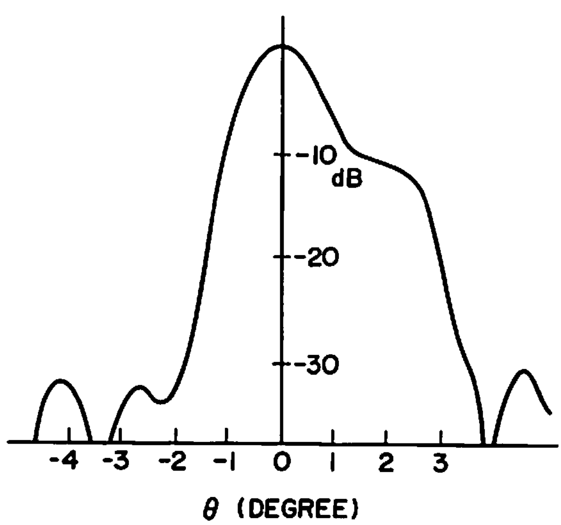

Fig. 2 Radiation Pattern
(Circular Polarization)

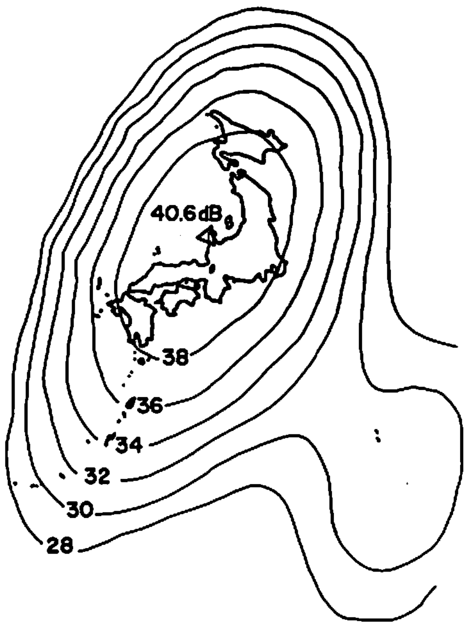

Fig. 3-b
(Linear Polarization)

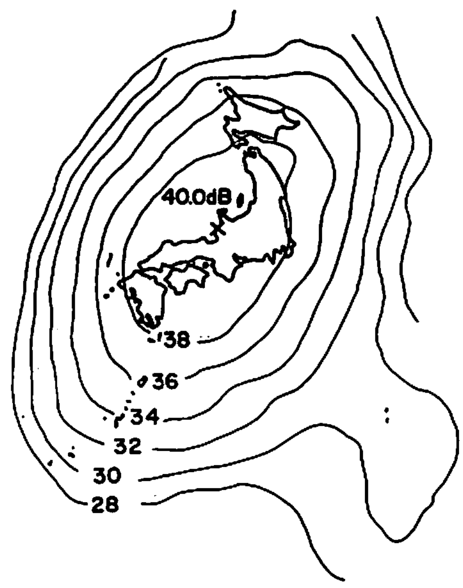

Fig. 3-b
(Circular Polarization)

Fig. 3 Radiation Pattern