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AN OFFSET CASSEGRAIN ANTENNA FOR THE SATELLITE COMMUNICATION SYSTEM EARTH STATION

Eiichi OGAWA, Tadashi TAKANO, Masaaki SHINJI

Yokosuka Electrical Communication Laboratory
Nippon Telegraph and Telephone Public Corporation
Take, Yokosuka, 238-03 Japan

Noriaki ISHIDA

Engineering Bureau, N.T.T.
Uchisaiwaicho, Chiyoda-ku, Tokyo, 100 Japan

Introduction

An offset Cassegrain antenna has attractive features for application in a satellite communication system earth station. It has low sidelobe directivity due to the absence of aperture blocking, and may also reduce the wind load on the antenna basis due to the flat and nearly horizontal reflector. However, in order to realize a commercially usable antenna, some difficulties, mainly arising from the structural asymmetries, should be solved.

An 11.5 meter offset Cassegrain antenna has been developed, and will be put to first practical use in the world in the Japanese domestic satellite communication system. This paper describes an outlines of earth station antenna requirements, contrivances specifically for an offset antenna, antenna configuration and several experimental results.

Antenna system requirements and design principles

The earth station antenna operates in the 20 and 30 GHz band, each having 3.5 GHz bandwidth. Required antenna gain is more than 65.8 dB and 68.7 dB at 19.45 GHz and 29.25 GHz, respectively. The antenna is planned to be installed on a telephone exchange office building in large cities, where the terrestorial radio relay networks are concentrated. Therefore, low sidelobe directivity is required over the wide angle range to avoid interferences between systems. Further, antenna weight and wind load should be small.

The wide angle directivity of the offset antenna was theoretically estimated using the measured results of the 11.5 meter axisymmetrical antenna [(1)] and the 2 meter offset shaped reflector model antenna [(2)]. It was shown that the offset antenna directivity would be superior by about 10 dB to that of the axisymmetrical antenna.

The wind load on the antenna basis on the building was investigated by wind tunnel experiments. Results show that the lift and the lateral force would be reduced to less than 1/4 compared with results from the axisymmetrical antenna.

The earth station antenna, especially for domestic satellite communication system, should not be expensive. The manufacturing cost of a large scale antenna increases almost proportionally to the number of main reflector panels. On the other hand the offset antenna needs reflector shaping for asymmetry cancelling and, consequently, for high gain or low sidelobe characteristics. However, conventional techniques [3] may not be employed for a large practical offset antenna, because the main reflector surface is deformed from the paraboloid, so that each panel has a different shape than any of the other panels. In order to solve this problem, a new technique has been developed. The reflector shaping technique is applied to the sub reflector and the beam-waveguide reflector, instead of to the main reflector, so that the main reflector shape remains a part of an axisymmetrical paraboloid. This technique is verified to be useful by means of model experiments, and is applied to the practical offset antenna design.

Antenna configuration

Figure 1 shows the configuration of the developed antenna installed on a building. The diameter is chosen as 11.5 meters to satisfy gain requirements. The limited steerable system is employed to lighten and simplify the structure. Az-El mount driven by two jackscrews is considered most suitable for an offset antenna. The feed horn and RF devices are fixed on the building. The 3-reflector beam-waveguide system is employed to simplify the feed system.

Because snow and rain water tend to stay on the reflector in the offset antenna, some countermeasures, such as a deicing heater, is used. Major performances are listed in Table 1.

Experimental results

Electrical performances are measured using a large antenna positioner, as shown in Fig. 2. For the 5.5 Km test range, the phase error correction is made by sub reflector deviation.

76 % and 69 % measured aperture efficiencies are obtained at full 20 and 30 GHz band, respectively, which agree well with the theoretical estimations.

Figure 3 shows near axis rediation patterns. The first sidelobes are below -20 dB. Unbalances in sidelobes are observed due to the reflector asymmetry in the El-plane. Wide angle rediation patterns are shown in Fig. 4, where the data for the 11.5 meter axisymmetrical antenna are also given. The patterns denoted by El = 45° are important to consider the interferences from the terrestorial radio relay systems. The low sidelobe characteristics are verified, and the 5 ~ 10 dB improvement can be achieved, compared with the axial symmetric antenna.

Conclusion

The developed offset Cassegrain antenna is confirmed to have good enough performances to be applicable to the earth station antenna. The design technique is verified by the experimental results.

The authors appreciate the cooperation of Mitsubishi Electric Co. in designing and manufacturing of this antenna.

References

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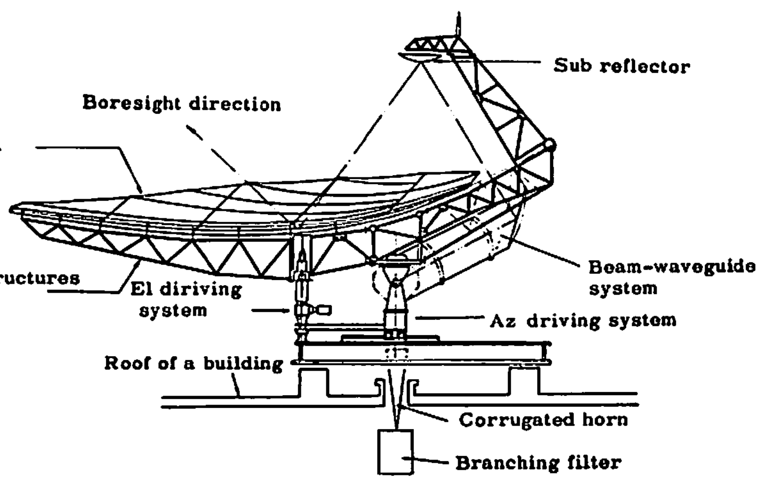

Fig. 1 Developed antenna configuration

Table 1. Major performances (*measured)

Aperture Diameter	11.5 m
Feed System	3-reflector Beam-waveguide with Corrugated Horn
Steering Angle	Az : ± 22° (± 6° continuous) El : ± 5° (continuous)
Surface Tolerance*	0.18 mm RMS
Weight*	19.4 tons
Frequency Band	17.7 ~ 21.2 GHz (Recieve) 27.5 ~ 31.0 GHz (Transmit)
Antenna Gain* (Efficiency)	66.3 dB (76 %) at 19.5 GHz 69.5 dB (69 %) at 29.5 GHz
Noise Temperature	Less than 20°K at El = 45°, at 18.75 GHz

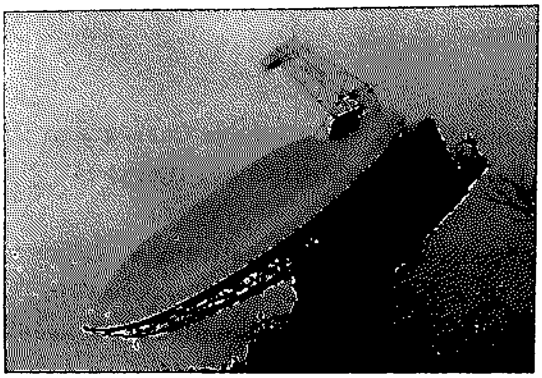

Fig. 2 Antenna on a large antenna positioner

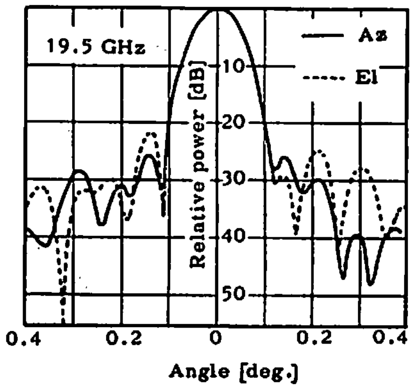

Fig. 3 Near axis radiation patterns

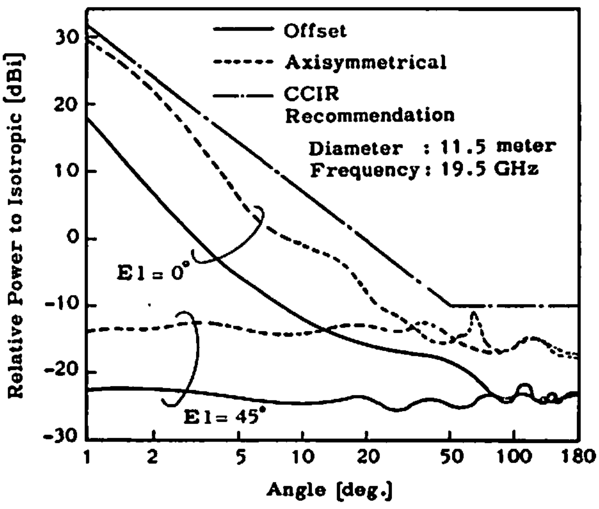

Fig. 4 Wide angle radiation pattern

3 dB below peaks