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Design of a Mesh Reflector Antenna for Satellite News Gathering

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1. Introduction

In the case of emergency television news and reports from a remote area, the video signals of these scenes are often transmitted to the broadcasting station via a satellite contribution link (SNG: Satellite News Gathering). In order to realize live broadcasting of these scenes, especially from abroad, portable antennas for SNG are required to be lightweight and easy to be carried. On the other hand, antennas for the earth station of the satellite communications should meet the reference pattern recommended by ITU-R [1] to avoid interferences to other satellite communications. In this paper, we describe the design of the mesh-reflector antenna for SNG, which can be deployed like an umbrella, and calculated radiation pattern of the designed mesh-reflector antenna.

2. Requirements for a Mesh Reflector Antenna for SNG

Requirements for an antenna for SNG are as follows.

(1) HD-TV signal transmission ability
(2) Portability
(3) Low side lobe characteristics
(4) Cost effectiveness

First, as standard HD-TV transmission systems for SNG, which are installed in NHK broadcasting stations, have the reflector aperture diameter of 1.5m and the rated output of 400W high power amplifier (HPA), the aperture diameter of mesh reflector required to be around 1.5m or above. Second, portability of a reflector antenna is required because the antenna for SNG is desired to be carried on a commercial airplane as a passenger's luggage which has a limitation of weight and physical size [2]. A mesh reflector antenna has an advantage with this respect. Third, ITU-R S.580-6 recommends that the gain of less than 10% of the side lobe peaks exceed the reference pattern (see Fig. 4, 5). Therefore, low side lobe designing is required as the surface of mesh reflector antenna has pillow effect which increases side lobes. Fourth, the manufacturing cost of mesh reflector antenna is important in order to be widely used.

3. Antenna configuration

We design the mesh reflector antenna in the Ku-band (14—14.5 GHz for uplink and 12.25—12.75 GHz for downlink), and its aperture diameter is 1.5m. We compared antenna configurations of a center-fed type and an offset-fed type. Table 1 shows the result of comparison. The center-fed type is superior in portability because its physical size is smaller than the offset-fed type of same aperture diameter. In addition, the feed horn and sub reflector can be held inside the ribs when the mesh main reflector is folded. The offset-fed type is superior in low side lobe characteristics because of absence of blockage in front of its reflector. The center-fed type is superior in cost effectiveness because the manufacturing cost of symmetric reflector is less than that of asymmetric one. Therefore, we selected a center-fed type.

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Table 1: Comparison of Mesh Reflector Antenna Configuration

Antenna Configuration	Center-fed type	Offset-fed type
Portability	Good	So-so
Low side lobe	So-so	Good
Cost effectiveness	Good	So-so

Figure 1 shows a side view of the mesh reflector antenna that we designed. The mesh-reflector antenna consists of a thin-wired mesh surface, parabolic ribs with sliding support, a feed horn antenna and a sub reflector. The thin-wired mesh is a grid fabric, which has 40 gauges in an inch, woven with stainless wire whose diameter is 0.06 mm. The parabolic ribs are connected to a ring which slides along a center struts. A feed horn antenna is supported by a wave guide tube penetrating the center of the mesh reflector. Above the feed horn antenna, a sub reflector is placed. The sub reflector is supported by a radome which is connected to the wave guide tube.

4. Design of a Feed Horn and Sub Reflector

We designed a dual mode horn antenna consisting of tube and flare as a feed of the mesh reflector antenna because the dual mode horn is lightweight and superior electrical characteristics for dual band use [3]. Figure 2 shows designed dual mode horn antenna. The angles $\alpha_1, \alpha_2, \alpha_3$ and the length l_1, l_2 was optimized to minimize the difference of the side lobe levels between E-plane and H-plane radiation pattern at the frequencies of both 14.25 GHz and 12.5 GHz. Figure 3(a) shows calculated radiation pattern of the designed horn at the frequency of 14.25 GHz and Figure 3(b) shows that of 12.5GHz. The radiation patterns in E-plane and H-plane well agree from 0 to 60 degrees.

Then, we designed the sub reflector with a parabolic main reflector. First, we designed the structure of the sub reflector with conventional method described in [4]. Figure 4 shows the calculated radiation pattern with conventional sub reflector design and the reference radiation pattern described in ITU-R Recommendation [1]. As the calculated radiation pattern of conventional design showed side lobe rising due to spill over of the outside path of the sub reflector, we enlarge the diameter of the sub reflector to prevent the spill over. But the side lobe increases since the spill over of H-plane cut is larger than that of E-plane cut and such tendency became worse at 14 GHz (off the optimized frequency of the horn antenna). Therefore, we designed oval sub reflector of which length of major axis was 0.29m and that of minor axis was 0.25m. Figure 4 shows the radiation pattern of the oval sub reflector. The side lobe due to the spill over decreased in the range over 20 degrees. But the first and second side lobe increased due to the blockage of the sub reflector.

5. Design of a Main Reflector with Mesh Surface

First, we measured the transmission loss of the mesh surface. Table 2 shows the result of the transmission loss measurement. We measured the transmission of a mesh material sandwiched in foamed polystyrene placed between facing horn antennas. The S21 value of –19.1 dB is intermediate level compared to other materials used as mesh reflector antennas [5, 6]. The S21 value of -19.1 dB gives the power flux density of 2.4 mW/cm^2 in the backward of the antenna when the transmitting power is 400 W and it is expected to enough protect the human body. In actual operation, the HPA is operated to be backed off from the rated output of 400W.

Second, in order to evaluate the effect of the periodic surface deviations from an ideal parabolic reflector, we calculated the radiation patterns varied with the number of the ribs in Figure 5. The more the number of ribs is increased to reduce the side lobes by the effect of the periodic surface deviations, the more the weight of antenna is increased. We selected 36 ribs because it decreased the main lobe gain by 0.3 dB and less than 10% of calculated side lobes exceeded the reference pattern in the frequencies of 14, 14.25 and 14.5 GHz (Table 3) within the off axis angle of

+80/-80 degrees. The effect of the radome that supported the sub reflector was not taken into account and it is left for further study.

5. Conclusion

We described the design of the mesh reflector antenna for satellite news gathering. First, we compared the configuration of a center-fed type with that of an offset-fed type. Second, we showed designed dual-mode horn antenna. Third, we showed the design of the sub reflector. Finally, we showed the calculated radiation patterns of a mesh reflector antenna with 36 ribs. The radiation patterns of the designed antenna met the reference pattern of the ITU-R Recommendation. For future work, we will evaluate the radiation patterns by experiment using a manufactured mesh reflector antenna.

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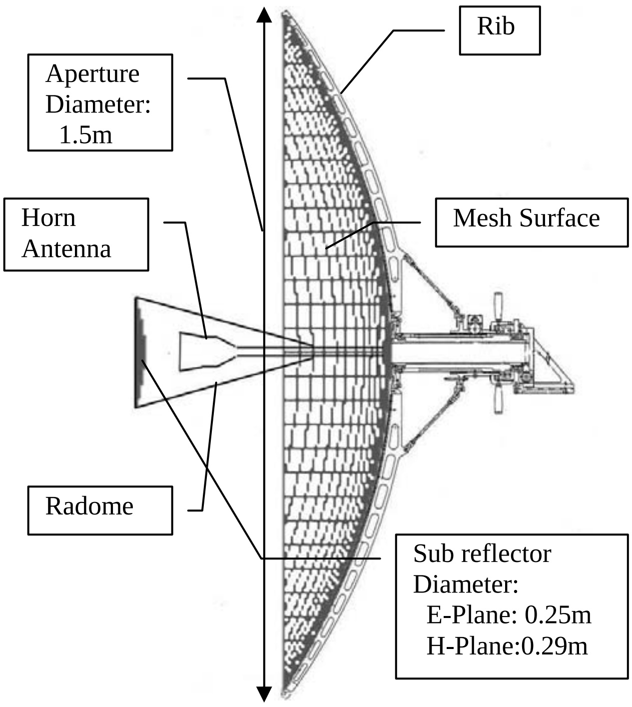


Figure 1: Side view of Mesh Reflector Antenna

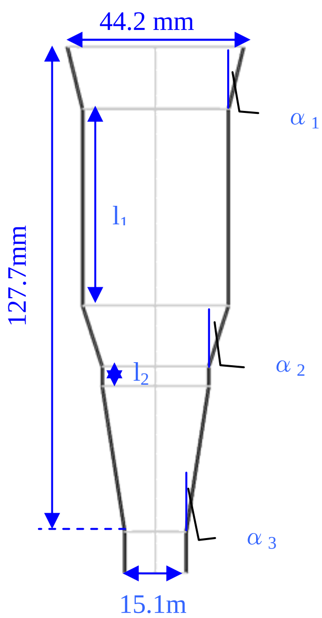
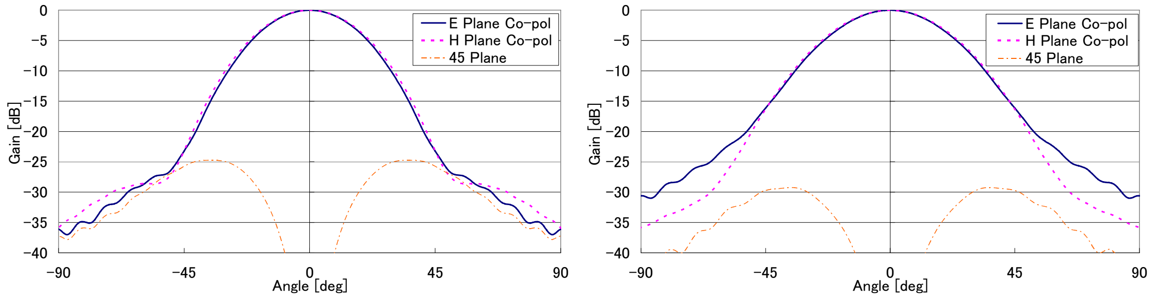
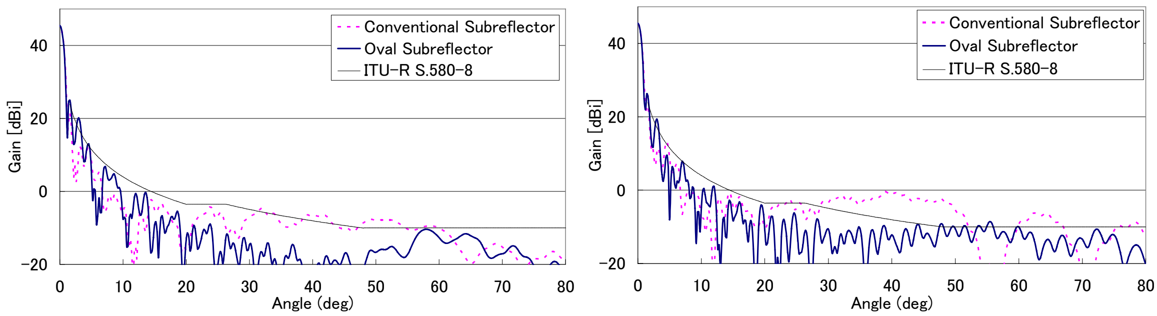


Figure2: Designed Dual-mode Horn Antenna



(a) 14.25 GHz (b) 12.5 GHz

Figure 3: Radiation Pattern of Designed Dual-mode Horn Antenna

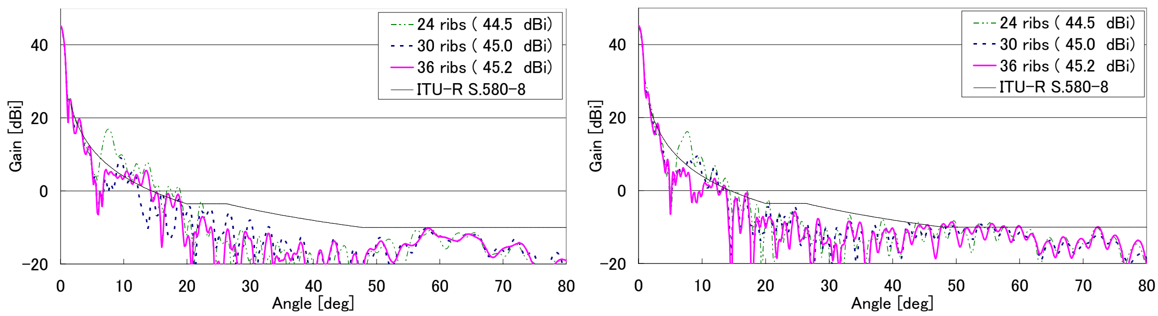


(a) E-Plane (b) H-Plane

Figure 4: Comparison of Radiation Pattern between Conventional Subreflector Design and Oval Subreflector Design (14.25 GHz)

Table 2 : Transmission Loss (S21) of Mesh Surface Material

Frequency [GHz]	14	14.25	14.5
S21 [dB] (φ0.06mm, 40guage/inch)	−19.9	−19.1	−20.1



(a) E-Plane (b) H-Plane

Figure 5: Comparison of Radiation Pattern Varied by Number of Ribs (14.25 GHz)

Table 3: Calculated Antenna Gain of Designed Mesh Reflector and Percentage of the Side Lobes Exceed the ITU-R Reference Pattern

Frequency [GHz]		14	14.25	14.5	12.25	12.5	12.75
Reflector Antenna Gain [dBi]		45.1	45.2	45.2	43.7	44.0	44.2
Side lob exceed the reference pattern[%]	E-Plane	3.78%	3.50%	7.44%			
	H-Plane	8.11%	3.89%	9.67%			