PORTABLE AND DEPLOYABLE ANTENNA FOR ETS-VIII

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Abstract

Experiments were performed to evaluate the electrical characteristics of a portable and easily deployed antenna that is proposed for use in experiments to be conducted with Engineering Test Satellite VIII (ETS-VIII). It was determined that the proposed antenna is practical and feasible for use with ETS-VIII.

1. Introduction

An Engineering Test Satellite VIII (ETS-VIII) for demonstrating next-generation mobile satellite communications and broadcasting will be launched in Japan in 2005 [1]. Japan's Communications Research Laboratory has scheduled high speed data rate communication experiments for mobile satellite communication by using a transportable earth station and ETS-VIII [1]. Therefore, we propose a portable antenna as the antenna for use with the transportable earth station to be used for these experiments.

The portable antenna is a parabolic antenna with a 400-mm diameter and a reflector made of a flexible conductive woven fabric. This antenna is stored in a thin case and is deployed by simply opening the case. By using this deployment method, a light, easily transportable antenna is achieved. In this paper, the structure of this portable antenna is described, and experiments to evaluate its electrical characteristics are reported. We demonstrated that a portable and easily deployable antenna is practical and feasible as an antenna for use with the transportable earth station to be used with ETS-VIII.

2. Structure of the antenna

An antenna for the ETS-VIII's transportable earth station requires the following performance characteristics:

1) S-band Transmit/Receive frequency,
2) Left-hand circular polarization,
3) 12dBi gain for a transmission rate greater than 1024kbps [2], and
4) it must be small and light.

Fig. 1 Photograph of portable antenna

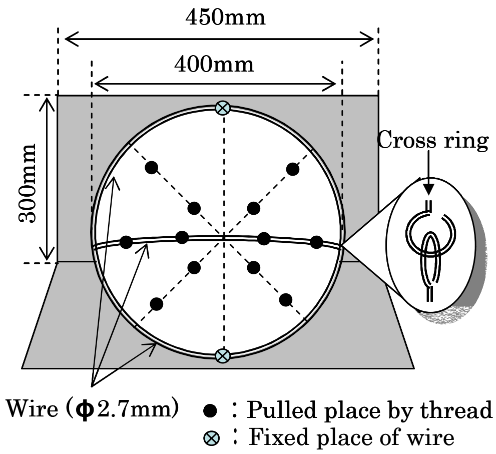

Fig. 2 Structure of portable antenna

The photograph of the antenna produced experimentally is shown in Fig. 1. In Figure 1, the right side shows the antenna deployed and the left side shows the antenna folded. This antenna is stored in a thin case made of wood board for ease of transportation. By opening the case, the antenna is deployed.

The structure of the antenna is shown in Fig. 2. The diameter of the antenna is the 400mm, F/D ratio is about 0.29, and the reflector surface was made of eight sheets of conductive woven fabric (the dotted lines in Fig. 2). This parabolic antenna was formed using three stiff 2.7-mm-diameter wires and 12 tension threads. The two stiff wires are used to form the circumference and each wire is mounted adjustably. By means of their arrangement, the reflector is deployed as the case is opened. Another stiff wire was used to form the parabola in the center of the parabolic reflector. Folding them at two points where these wires cross made possible storing the antenna in a flat case.

The conductive woven fabric's usual purpose is to be used as an electromagnetic shielding material. Its thickness is 0.125mm, the surface density is $72 g/m^2$, and the surface resistance is 0.05Ω/sq.

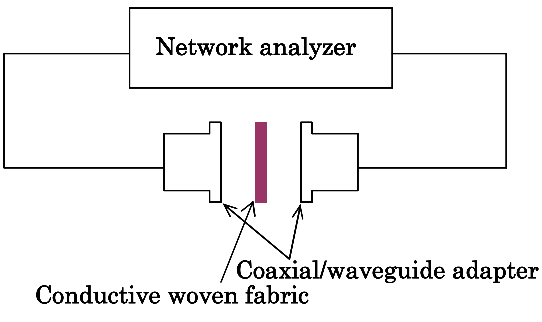

Fig 3 Return loss and transmission loss measurement system

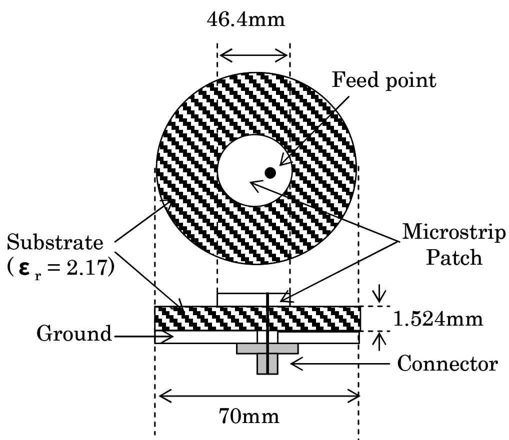

Fig. 4 Structure of primary feed antenna

To determine whether this conductive woven fabric could be used as a reflector material, we measured reflector loss and transmission loss. As shown in Fig. 3, we put the woven fabric between two coaxial/waveguide adapters (1.7 GHz-2.6 GHz) and measured the reflection loss and transmission loss by using a network analyzer. At frequency 2.5 GHz, the reflection loss and transmission loss were 0.03 dB and 74 dB, respectively. This result demonstrated that the woven fabric reflected a radio wave almost perfectly.

As a primary feed antenna, we used a circular patch antenna because it could be easily stored in a thin case. The structure of the feed antenna is shown in Fig. 4. For simplicity, linear polarization was used. The diameter of the microstrip patch shown in the figure is 46.4 mm, and the substrate is grass cross teflon in which the thickness and dielectric constant are 1.524 mm and 2.17, respectively. In order to possibly decrease blocking loss, a circular substrate of 70 mm diameter was used. The feed method of the patch antenna was pin feed, and gain was 7.53 dBi.

3. Experimental results

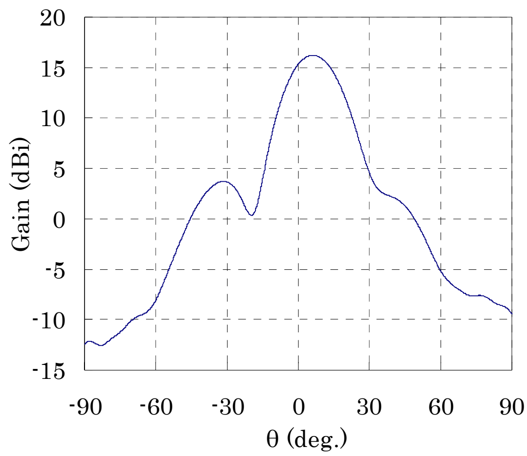

Fig. 5 Antenna radiation pattern

We measured the radiation pattern and gain of the deployable antenna shown in Fig. 2 with the microstrip antenna feed shown in Fig. 4. In order to decrease the blocking loss if possible, the feed antenna was fixed in a polyester resin rod (length: 450 mm, width: 30 mm, and depth: 25 mm) that has small transmission loss. The feed antenna was placed about 11.5 cm from the reflector center for tapered irradiation of about 10dB in order to reduce spillover loss.

The measured radiation pattern is shown in Fig. 5. We obtained results demonstrating that the gain was 16.38 dBi, the 3 dB beam width was 22.15 deg., and the efficiency was about 40 %. Since this measured gain is greater than the 12dBi required for ETS-VIII, this portable and easily deployed antenna is clearly practical and feasible to be used with the transportable earth station for ETS-VIII. However, the efficiency was not as acceptable. In generally, the efficiency of a parabolic antenna is dependent on blocking of the primary feed antenna, spillover, and reflector surface accuracy. Since a 10 dB tapered irradiation was done for the measurement, an efficiency of about 73% should have been obtained according to the literature on this subject [2] when only irradiation efficiency and spillover efficiency are considered. However, the efficiency was less than 73%, because blocking loss and loss due to the reflector's surface roughness must be considered. Therefore, in order to obtain higher efficiency, we must to decrease the blocking loss caused by the feed antenna and that caused by reflector surface roughness.

4. Conclusion

In this paper, a portable deployable antenna of transportable earth station for mobile multi-media high data rate communication experiment using ETS-VIII is proposed. An outline of its structure and experimental measurements of its electrical performance are reported.

Experimental results demonstrated that the conductive woven fabric used as antenna reflector surface has excellent reflection characteristics: reflection loss and transmission loss were 0.03dB and 74dB, respectively. That fabrication of a light, thin, foldable antenna can be achieved by using this conductive woven fabric was proven. That this antenna can be stored in and deployed from a thin case was also demonstrated. Since conductive woven fabric is flexible and the portable antenna must be folded, achieving a reflector with high surface accuracy is difficult. However, our gain measurements showed that the measured gain (16.38dBi) for this antenna is higher than that required (12dBi) for use with ETS-VIII. Therefore, a portable and easily deployable antenna was demonstrated to be practical and feasible as an antenna for use with ETS-VIII.

In the future, we will investigate methods for reducing blocking loss and improving the reflector surface. We will also examine common transmit/receive and circular polarization for the antenna. In addition, we will investigate the possibility of a smaller sized portable antenna that can be stored in and deployed from an A4 sized case.

Reference

[1] N. Hamamoto, Y. Hashimoto, M. Sakasai, Y. Tsuchihashi, and M. Yoneda, "An experimental multimedia mobile satellite communication system using the ETS-VIII satellite," AIAA-98-1301, A collection of technical papers of the 17th International Communications Satellite System Conference, pp. 408-416, Feb. 1998.

[2] W. L. Pritchard and A. Sciulli, "Satellite communications system engineering," Keigaku Press, pp. 318-320, Nov. 1988.