Proceedings of ISAP2012, Nagoya, Japan

A Ku Band Small Reflector Antenna Using Backfire Primary Radiator for Satellite Communication System on Board Vessel

[#] Shin-ichi Yamamoto, Shuji Nuimura, Tomohiro Mizuno,
Yoshio Inasawa, Hiroyuki Sato, Makio Tsuchiya
Mitsubishi Electric Corporation,
5-1-1 Ofuna, Kamakura, Kanagawa, 247-8501 Japan,
Yamamoto.Shinichi@dr.MitsubishiElectric.co.jp

1. Introduction

Recently, the demand for mobile broadband communications on aircrafts and ships has increased. There are a lot of worldwide demands for high-speed data communications in sea area. Introduction of the earth stations on board vessels (ESVs) system using the Ku band satellite communications systems has been started [1-3]. The authors propose an antenna for the system. It is necessary to conform to international and regional standards and regulations all around the world. For this purpose, antenna needs to be designed to achieve low side lobe with keeping high antenna efficiency. In this paper, we report the design of the small reflector antenna for the Ku band satellite communications system on board vessel.

2. Antenna Structure

Figure 1 shows the antenna structure, which has self-supported backfire primary radiator [4-5] in the centre of a main reflector. A backfire primary radiator consists of a circular feed waveguide and a hat structure supported by a dielectric spacer.

There are three key points of the antenna design for low side lobe level and low cross polarization. They are a backfire primary radiator with a small diameter (small blockage area), the suppression structure of a surface current on the feed waveguide, the hat structure which produces rotational symmetry electromagnetic fields.

For high antenna efficiency, a sharp primary radiation pattern with shallow reflector or a wide primary radiation pattern with deep reflector are chosen in order to suppress the spill-over power from the main reflector. However, for the sharp primary radiation pattern, blockage area by the primary radiator or the sub reflector becomes large and side lobe level at the near axis becomes high. We adopt a small backfire primary radiator with a deep reflector.

A surface current on the feed waveguide degrades side lobe patterns especially in near axis of the E-plane. The surface current is suppressed by the corrugation loading in the whole feed waveguide surface and chokes around the aperture of the feed waveguide.

The hat has $\lambda/4$ grooves in order to improve the rotational symmetry of the electromagnetic field. The combination of the vertical (parallel to the waveguide axis) and horizontal (normal to the waveguide axis) grooves is effective in stopping the spill-over power from the hat and the main reflector, even if the hat diameter is small. Since reflective conditions differ between E- and H-plane, rotational symmetry is degraded and the cross polarization level is raised. The slope and vertical grooves, instead of the horizontal groove, are suppressed the spill-over, with rotational symmetry maintained.

3. Radiation pattern

Figure 2 shows a photograph of a designed antenna for the Ku band satellite communications system on board vessel. Aperture diameter of the main reflector is 60λ.

An analytical model for the radiation pattern of the antenna is a combined method of electromagnetic analysis and high frequency approximation (physical optics, PO). The electromagnetic fields around the backfire primary radiator are calculated by the finite element method (FEM). The currents at the reflector surface are calculated from the electromagnetic fields, and a radiation pattern is calculated by integrating them. This calculation procedure can obtain accurate radiation patterns compared with the conventional calculation method of using near or far field radiation patterns of the primary radiator.

Figure 3 shows antenna measurement equipment. An inclined fixer is used in order to point the antenna in the direction of 30deg which is the usual elevation angle of satellite station in mid-latitude region. Figures 4 and 5 show measured and calculated results at transmission frequency band in E-plane (horizontal polarization) and H-plane (vertical polarization), respectively. Although the antenna is measured with a radome, the calculated results are not included affects of the radome. The low side lobe characteristic is achieved over the wide angle range.

4. Conclusion

We reported the design and measurement results of the small reflector antenna for the Ku band satellite communications system on board vessel. The backfire primary radiator, the suppression structure of the surface currents on feed waveguide, and the hat structure with rotational symmetry electromagnetic field are applied to the antenna design. The low side lobe characteristic is achieved over the wide angle range.

References

[1] Y. Konishi, et, al. “Airborne Antenna for Broadband Aeronautical Satellite Communication Systems,” IEICE Trans. on Comm., vol.J88-B, no.9, pp.1613-1623, Sept. 2005, in Japanese.

[2] M. Satoh, et al., “Helicopter-Satellite Communication System Developed for Transmission of Disaster and Emergency Information,” 21st International Communication Systems Conference and Exhibit, AIAA 2003-2319, 2003.

[3] Y. Inasawa, et al., “Design Method for Low-Profile Dual Shaped Reflector Antenna with an Elliptical Aperture by the Suppression of Undesired Scattering,” IEICE Trans. Electron., vol.E91-C, no.4, pp.615-624, April 2008.

[4] P.S. Kildal, et. al, “The Hat Feed: A Dual-Mode Rear-Radiating Waveguide Antenna Having Low Cross Polarization,” IEEE Trans. Antenna and Propag., Vol.AP-35, No.9. Sept. 1987.

[5] J. Yang, et. al., “Calculation of Ring Shaped Phase Centers of Feeds for Ring-Focus Parabolids,” IEEE Trans. Antenna and Propag., Vol.48, No.4. April 2000.

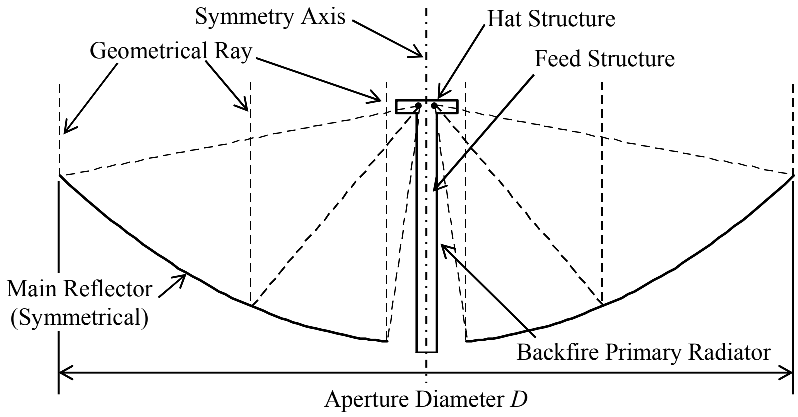

Figure 1: Antenna structure

Figure 2: Photograph of ESV antenna

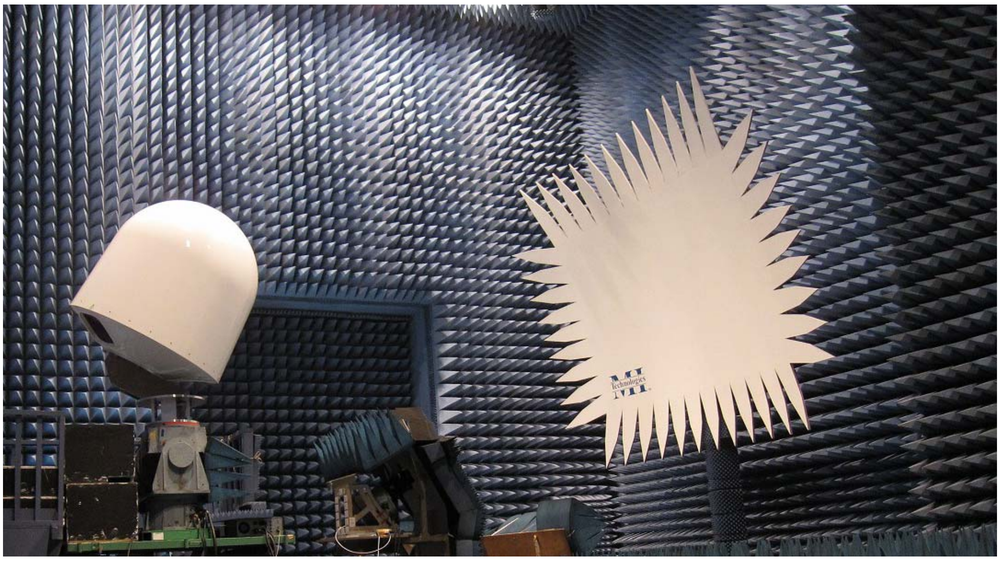

Figure 3: Antenna measurement equipment

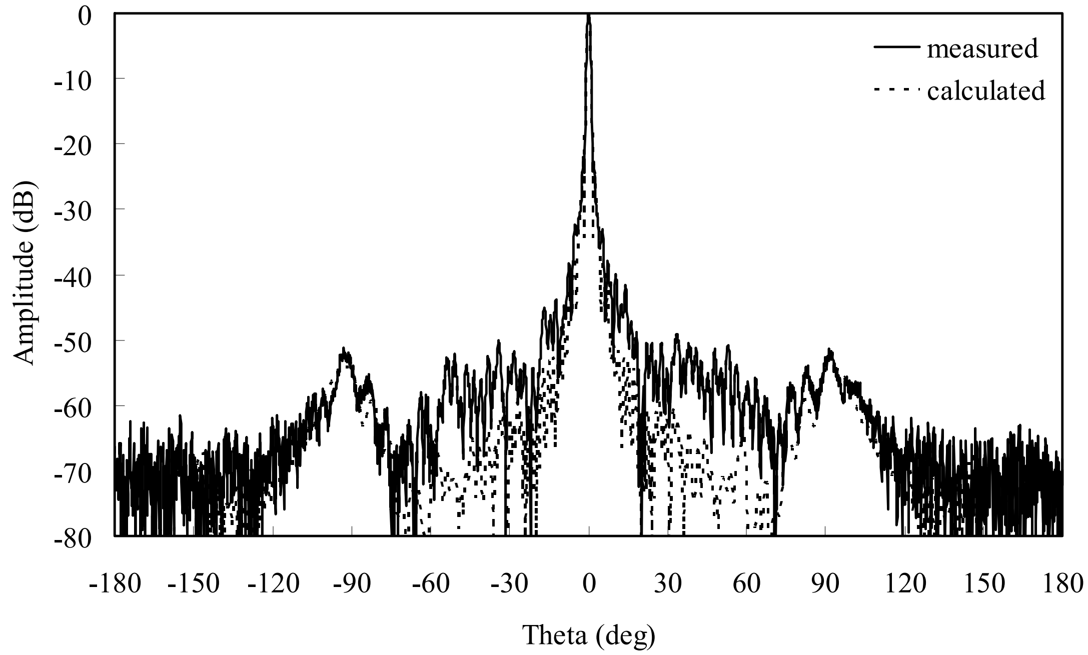

Figure 4: Radiation Pattern in E-plane

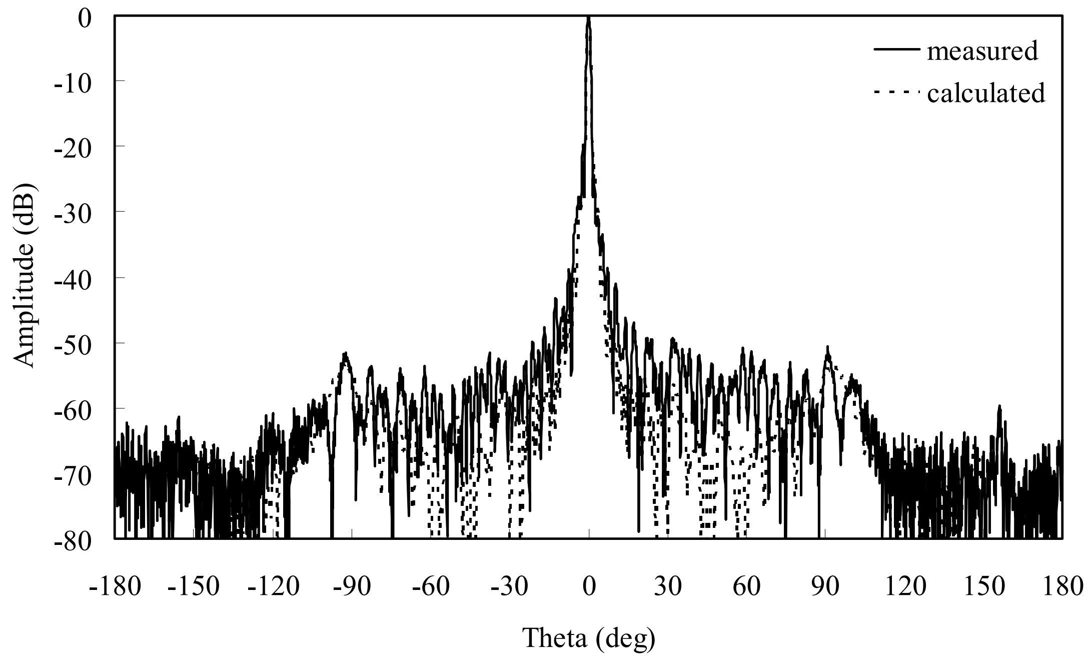

Figure 5: Radiation Pattern in H-plane