Ka-band Shaped Dual Gridded Antenna for Transmit and Receive use

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1. Introduction

Ka-band shaped dual gridded antenna for both transmit and receive use with improved intercostals design has been demonstrated for broadband satellite communication. The dual gridded antenna (DGA) consists of grid front reflector, rear reflector and intercostal that support both reflectors has feature of orthogonal purity of two polarizations [1]-[2], in ka-band, however, few papers have been reported the radiation performance such as cross polarization and beam shaping. Especially careful design needs to be taken into account for the intercostal from which reflection and diffraction is larger than that in lower frequency. Further, in ka-band, since transmit and receive frequency separated as 20GHz and 30GHz band, beam performance corresponds to each frequency is fairly varied, which means that required beam performance can not be easily obtained by one feed and one reflector configuration. In this paper, shaped DGA for dual band on transmit and receive use has been designed nevertheless dual frequency is apart 40%. Also practical 2.2 meter-size DGA has been fabricated and tested in ka-band and appropriate performance has been verified thru test results.

2. Configuration of dual gridded reflector

Fig.1 shows the outline of dual gridded antenna. The horizontal polarization wave is reflected on the front reflector that has horizontal direction grid, while the vertical polarization is reflected on the rear reflector that consists of grid or solid without grid. The front and rear reflectors are supported by outer ring and the intercostal, which hold reflectors firmly against severe vibration in launching. Further this combined reflector configuration suffers from difference of wide temperature range. Therefore the intercostal needs to be designed not only standing for vibration but also reducing thermal deformation, however, in electrical performance of view, the reflection and diffraction from the intercostal lead beam shaping and sidelobe level to worse.

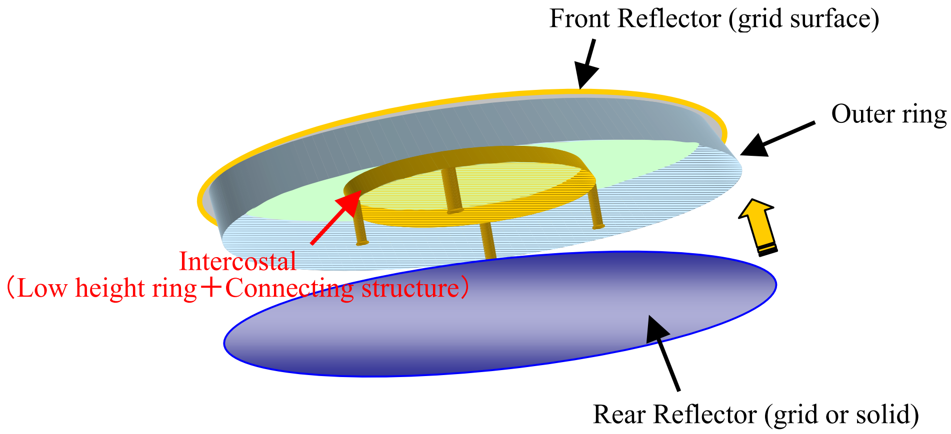


Fig.1 Configuration of DGA with improved intercostal

For aim of solving above problems, improved intercostal configuration that has low height ring and connecting structure as shown in Fig.1 has been introduced, and its effectiveness has been verified [3]. This configuration can reduce reflection and diffraction from the intercostal surfaces by removing intercostal volume, and this low height ring is also effective to reduce thermal deformation of the front reflector as well as conventional high height ring because ring shaped structure can inherent hold out of surface deformation even though its height is low. Outer ring does not affect on the performance degradation since it is located outside area of wave radiation.

3. Beam shaping design with improved intercostal

Antenna beam shaping is calculated by PO (Physical Optics) method [4] with taking into account the grid on the front reflectors and the reflection from the intercostal as shown in Fig.2. The front reflector and the intercostal consist of sandwich layered configuration, skin, core and skin.

Fig.3 shows beam shaping results with/without the intercostal in Japan area coverage for example, Fig.3(a) shows the case without the intercostal, Fig.3(b) shows the case with high height intercostal, which corresponds that the intercostal is filled up the space between the front and rear reflectors and Fig.3(c) shows the case with low height intercostal, which means the height is about quarter in comparison to the high height. It is noticed, in Fig.3 (b), contour variation level is large about several dB of gain and raised up 10dB of sidelobe level. On the other hand, in Fig.5(c), that level is relatively small and gain variation is less than 0.5dB. From these figures, the effectiveness of low height intercostal can be seen.

Next, the beam shaping for dual band operation is investigated. Since transmit and receive frequency is separated as 40% apart in 20GHz band and 30GHz band, inherently same beam shaping does not be obtained in separated frequency in one feed and one reflector. To conduct optimization in such wide frequency separation and to facilitate optimization convergence to be fast, the additional coverage method has been introduced for considering beam shaping frequency response. This optimization procedure can realize fast convergence of beam shaping, and designed results are shown in next section 4.

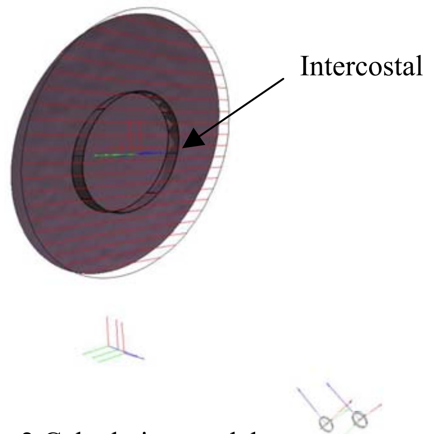
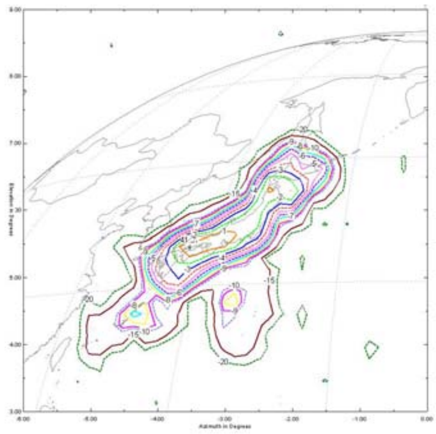
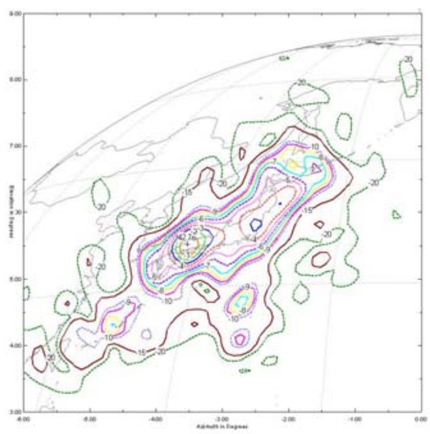


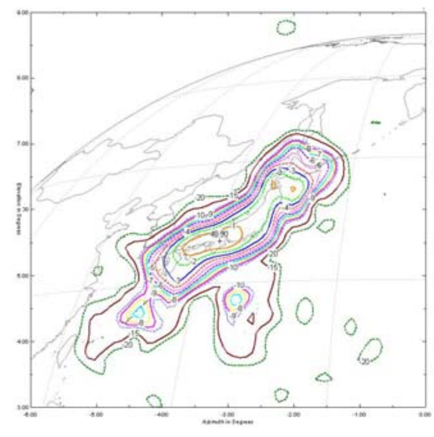
Fig.2 Calculation model



(a) without intercostal



(b) with high height intercostal



(c) with low height intercostal

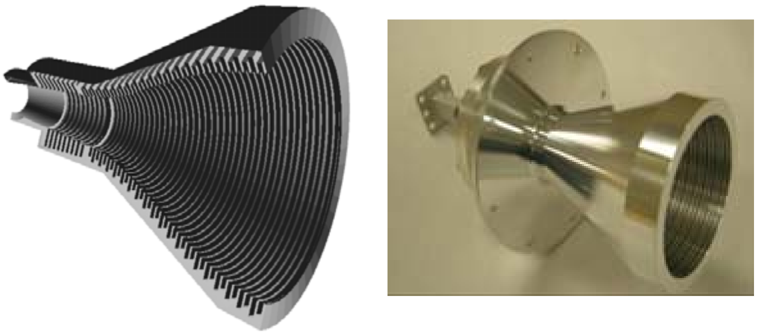
Fig.3 Comparison of beam shaping w/wo intercostal (rear reflector)

4. Fabrication and test results

In ka-band dual band operation for transmit and receive, dual band corrugated horn has been designed and manufactured of which designed CAD model and photo are shown in Fig.4 (a) and 4(b), respectively. Dual depth corrugation [5] is applied for dual band operation, which leads horn axis length to about half in comparison to general broad band corrugated horn.

The beam shaping for dual band optimization procedure has been applied for both 20GHz and 30GHz band, that is 40% apart, and 2.2 meter-sized shaped DGA were manufactured as shown in Fig.5. The front reflector is composed of sandwich honeycomb panel made by aramid fiber reinforced plastic and polarization grid is patterned on the surface. The rear reflector is composed of honeycomb sandwich panel made by carbon fiber reinforced plastic (CFRP), which does not have grid patterns. Rear and front reflectors are connected by the intercostal and outer ring, which are the part of circular cylinder whose axis is along the antenna axis.

Fig.6 (a)-(d) shows comparison of calculated and measured contours of rear reflector at 20GHz and 30GHz, respectively. Fig.7 (a) and (b) shows measurement of cross polarization of which more than 30dB discrimination was confirmed in ka-band.



(a) Dual depth corrugation (b) Fabrication

Fig.4 Dual band profiled corrugated horn

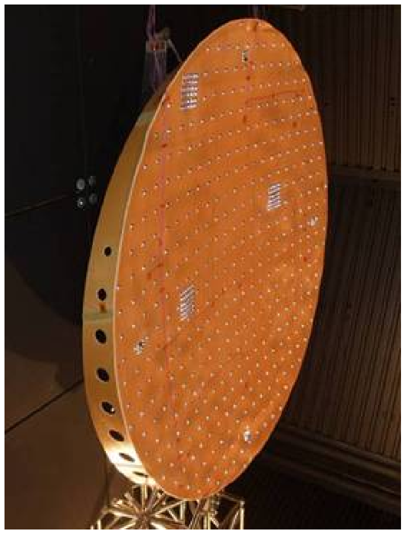


Fig.5 Manufactured dual gridded reflector (Diameter 2.2m)

5. Conclusions

Novel design and test results of dual band shaping DGA having improved intercostals has been demonstrated in ka-band. To conduct optimization in transmit and receive frequency, the additional coverage method has been introduced for considering beam shaping frequency response. For ka-band demonstration, dual depth corrugated horn and 2.2 meter-size shaped DGA has been manufactured and tested. The measurement results showed that dual band shaped beams were in good agreement with designed beams and cross-polarization level less than -30dB was obtained, and the validation of the DGA in ka-band has been confirmed. This novel shaping DGA can utilize four functions such as both vertical and horizontal polarizations, both transmit and receive frequencies in one antenna.

Acknowledgments
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References
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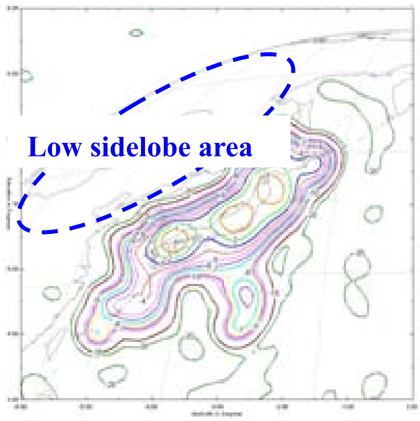
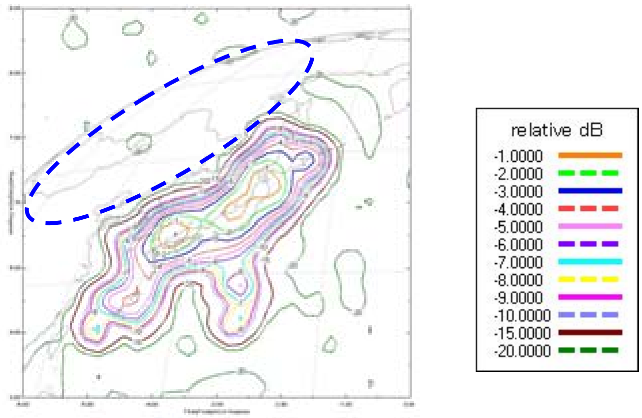
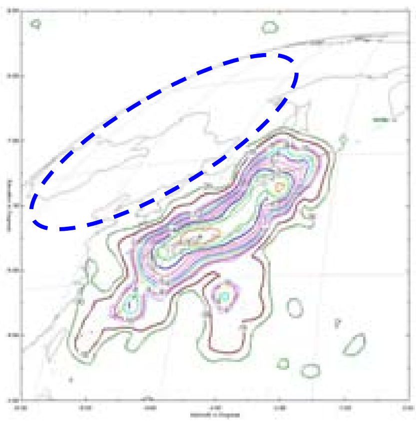


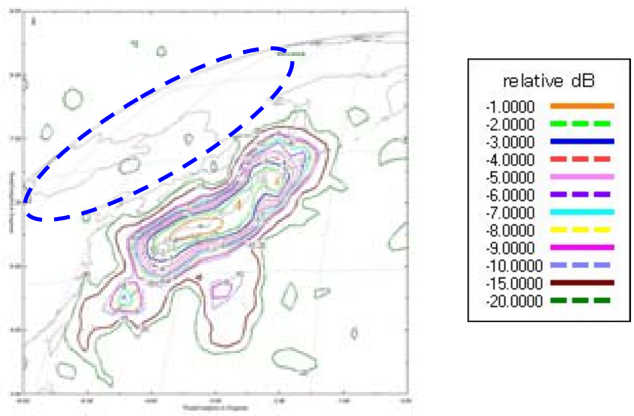
(a) Design (20GHz)



(b) Measurement (20GHz)

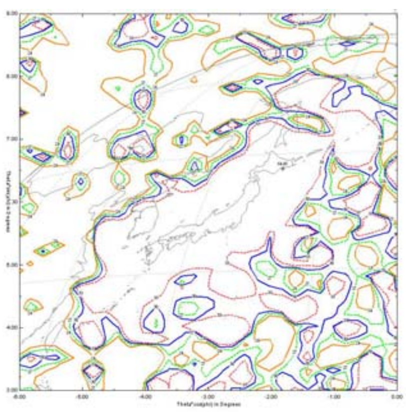


(c) Design (30GHz)

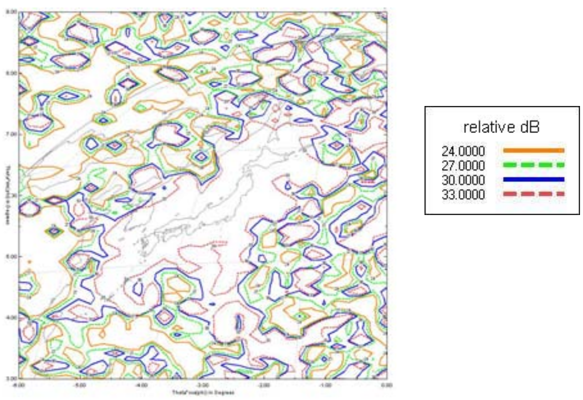


(d) Measurement (30GHz)

Fig.6 Comparison of calculated and measured radiation patterns (rear reflector)



(a) Measurement (20GHz)



(b) Measurement (30GHz)

Fig.7 Measured cross polarization (rear reflector)