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PLANAR ARRAY RECEIVING ANTENNA FOR SATELLITE COMMUNICATIONS

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1. INTRODUCTION

Recentry in Japan, satellite communications in Ku-band has come into commercial use with SUPERBIRD and JCSAT, and it is used for business network, CATV, and so on.

Generally, conventional parabolic reflector antennas are used for the receiving antenna, but planar antennas are desired to be the same as in the direct broadcasting system (DBS) case, because it is small,easy to set up, and easy to transport. On the other hand, the receiving antenna for satellite communication must be larger than that for DBS, because of the difference in satellite E.I.R.P. But efficiency of the large planar array antenna is lower, because of its feeding loss.

We have developed a new planar array antenna, in which a few LNA are put into the feeding network and high equivalent efficiency is realized. This paper describes design concept, configuration and performance of the antenna.

2. DESIGN

In a microstrip array antenna, if the aperture size increases, the antenna efficiency decreases due to feeding loss, and the antenna G/T is lower than that of the parabolic reflector antenna. To compen -sate this feeding loss, we adopted a method of dividing the antenna into several sub-arrays and putting a Low noise amplifier (LNA) in to the feeding network for each sub-arrays. A model of this method is shown in Fig.1.[1] In this figure, the sum of L_1 and L_2 is the total loss of the antenna. G/T of the antenna is,

$$(G / T) = Ga / Ts \tag{1}$$

where,

$$Ts = Ta + (L_1 - 1)T_0 + L_1 T_1 + \{(L_2 - 1)T_0 + L_2 T_r\} L_1 / G_1 \tag{2}$$

Calculated G/T is shown in Fig.2. In this figure, N is a number of sub-arrays. It is found that, if N increases, feeding loss before

LNA (L_1) decreases, so antenna G/T becomes greater.

On the other hand, antenna G/T must be greater than 16dB to obtain good receiving performance from Hokkaido to Kyushu. So,design target of 17dB for antenna G/T was set, and 900mm aperture size L and 6 division number N were selected.

3.Antenna configuration

A photograph of the developed planar array antenna is shown in Fig.3 and the configuration of the antenna is shown in Fig.4. This antenna consists of 6 sub-arrays, 6 LNAs, a power combiner and a LNB. (Low noise block converter) Each sub-array is a triplate line fed microstrip array antenna with about 280 elements,and total number of elements is about 1600. In each LNA, a HEMT-FET is employed. Its gain is about 11dB,and its noise figure is less than 1.2dB. Moreover, sub-arrays and a power combiner are composed on a thin film, and LNA boards is put into a same plane, so the antenna is very thin and its thickness is less than 76mm.

4.Experimental results

Electrical and mechanical performances are summarized in Table 1. G/T greater than 16dB was obtained in all frequency bands,and 16.8dB was obtained in 12.5GHz. At this frequency, equivalent efficiency (sub-array efficiency) is greater than 60 %.

Figure 5(a) shows the H-plane pattern at 12.5GHz and Fig.5(b) shows the E-plane pattern at 12.5GHz. It was found that measured patterns are in good agreement with calculated patterns in both planes, and that high cross polarization discrimination (XPD) performance ($\geqq$40dB)has been obtained.

Further, some receiving tests have conducted at Kitami City and Kagoshima City. Clear pictures have been obtained at both places.

5.Conclusion

A planar array receiving antenna was developed for Ku-band satellite communications. It has 970mm×970mm aperture (electrical size is 900mm×900mm) and is only 76mm thick. Its G/T is greater than 16dB in all CS frequency band. It is appricable for use in wide area,from Hokkaido to Kyushu.

Reference

(1) W.L.Pritchard, J.A.Sciulli, Satellite communication systems engineering, prentice-Hall,inc. 1986

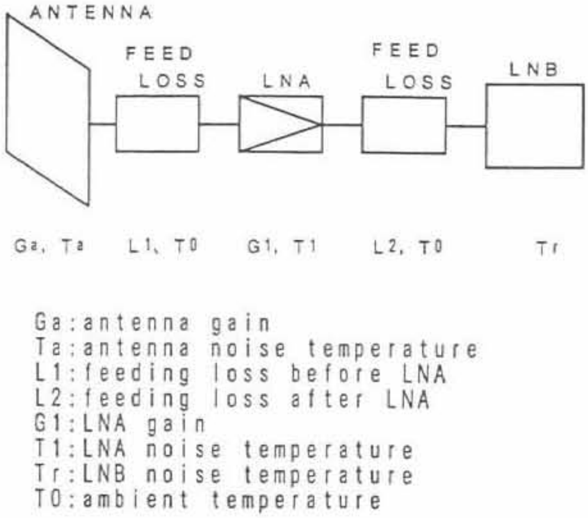


Fig.1 Calculation model of the antenna

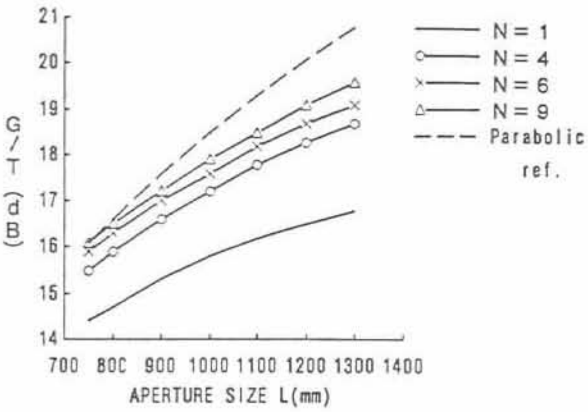


Fig.2 Calculated G/T

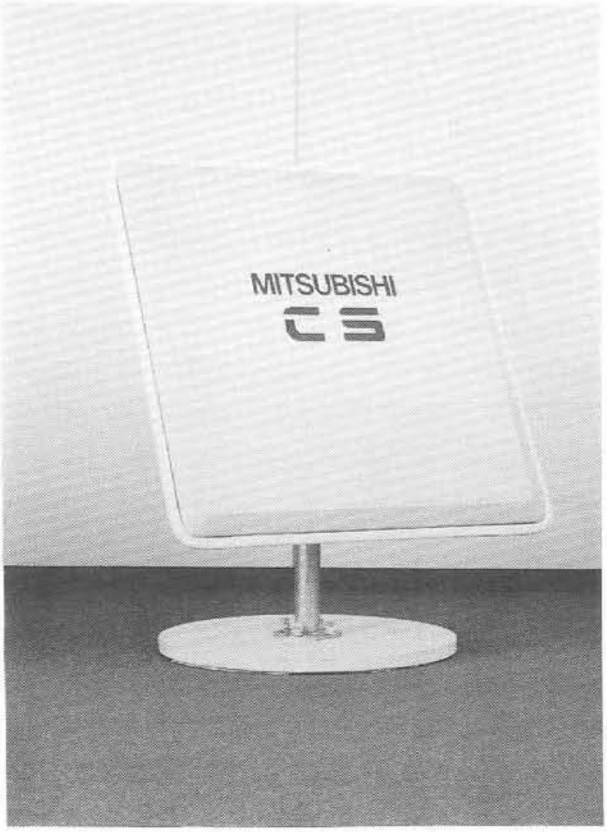


Fig.3 Developed planar array antenna

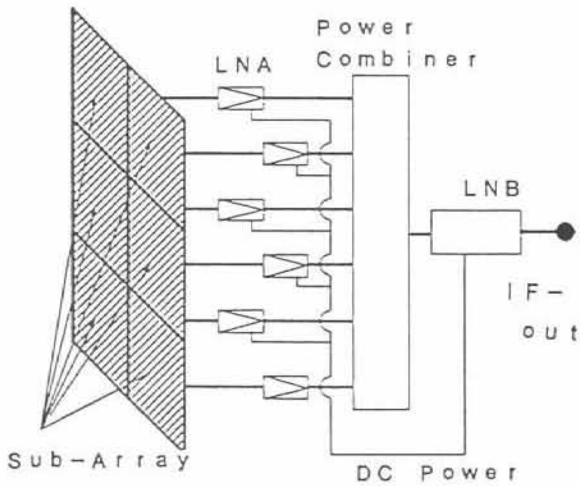
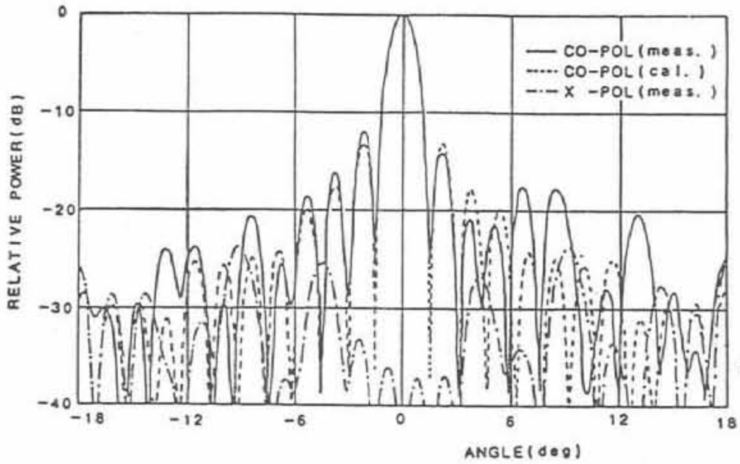


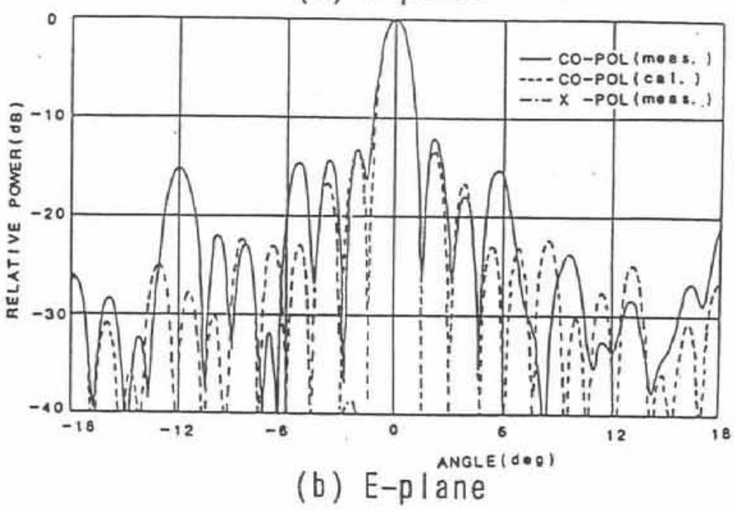
Fig.4 Configuration of the antenna

Table 1 Electrical and Mechanical Performance

Frequency	12.25GHz～12.75GHz
Polarization	Vertical or Horizontal
Gain	≧47dB (with LNA)
Output VSWR	≦1.7
G／T	≧16dB
XPD	≧40dB
Dimensions	970(W)×970(H)×76(D) (mm)
Weight	15kgf
Rated Wind Velocity	50m／s



(a) H-plane



(b) E-plane

Fig.5 Radiation pattern at 12.5GHz