TRADEOFF STUDY ON RECONFIGURABLE MULTIBEAM ANTENNAS

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1. Introduction

Reconfigurable multibeam antennas radiate multiple contoured beams whose shapes can be changed according to the requirement. They are expected to be useful for future communications satellite applications. Two types of reconfigurable multibeam antennas have been studied : (1) a direct radiating array antenna (DRAA)[1], (2) a array fed reflector antenna(AFRA)[2]. In this paper, tradeoff study between these two antennas is performed from the point of view of spacecraft applications.

2. Tradeoff study between two antenna types

The important properties to evaluate reconfigurable multibeam antennas are the beam shaping capability, the reconfigurability, and the multibeam capability.

We compare the size, comlexity, and loss of beam forming network (BFN) of the above two reconfigurable multibeam antennas with considering these capability separately in case of covering the specified regions on the earth from the geostationary satellite.

Beam shaping capability vs. BFN

A shaped beam is considered to be a composition of plane waves (component beams) with appropriate weight which propagate along different directions. The beam shaping capability depends on the beamwidth of the component beam. As the component beamwidth is narrower, the beam shaping capability increases. So, when the array antenna diameter of the DRAA and the reflector diameter of the AFRA are equal, the beam shaping capabilitis of both antennas are equal.

The feed array diameter of the AFRA depends on the antenna configuration and the size of the coverage. Fig.1 shows the relation between the feed array size d/D and the subtended angle ψ of the AFRA in case of covering the earth's disk. When the subtended angle takes a commonly used value, that is about 40°, the feed size, and also the BFN size are smaller than that of the reflector. When coverage is a portion of the earth, the feed size and the BFN size becomes much smaller.

As a result, the feed array size of the AFRA is smaller than that of the DRAA with the same beam shaping capability. The number of feed horns of the AFRA is also smaller, and the BFN structure is simpler.

Reconfigurability vs. BFN

The shaped beam is reconfigured by changing the weight of the component beams.

The component beam of the DRAA is formed by controlling a phase distribution of all feed horns. So, both amplitudes and phases of all feed horns are changed in order to alter the weight of component beams which form the shaped contoured beam. From this reason the DRAA requires both variable power dividers (VPDs) and variable phase shifters (VPSs) in order to alter the contoured beam shape.

On the other hand, the component beam of AFRA is formed by exciting only one feed horn. So, the contoured beam shape is alterd as the amplitudes of feed horns are changed. Therefore, the AFRA requires only VPDs in order to change the beam shape. Furthermore, it is possible to reduce the number of VPDs by using fixed sub-BFNs.[2]

Fig.2 shows block diagrams of BFN for reconfigurable antennas. The

AFRA with fixed sub-BFN has the advantages of simpleness and low loss in BFN structure.

Multibeam capability vs. BFN

In order to radiate multiple shaped beam, the number of feed arrays must be same as the number of the beams.

When the DRAA generates multiple beam, the individual arrays are required for each beam, and the total feed size and BFN size becomes large.

When the AFRA generates multiple beam, the individual feed arrays are required for each beam like the DRAA, but the reflector is used in common. The individual feed size and BFN size is smaller than that of the reflector as described above. And as the sum of all coverages is smaller than, or as small as the earth's disk, the total feed size and BFN size is also smaller than that of the reflector as shown in Fig.1.

So, the AFRA is more advantageous than the DRAA because of its BFN size.

3.Calculated results

Setting the array diameter of the DRAA approximately equal to the reflector diameter of the AFRA, the radiation patterns of both antennas are calculated.

Fig.3 shows calculated reconfigurable antenna models of the DRAA and the AFRA. The reflector diameter of the AFRA is 32-wavelengths, and the apature size of the DRAA is approximately equal to that of the AFRA. The number of feed horns is 23 in the AFRA , and 91 in the DRAA.

Fig.4 shows calculated radiation patterns of two different types of reconfigurable antennas. The shaded areas indicate the coverage of North America and Europe. The amplitudes and phases of all feed horns are changed according to the spacecraft locations. In this figure, solid lines represent equi-gain line of the minimum coverage area gain (MCAG), and broken lines represent 30dB lower than the MCAG.

The beam shaping capability of the AFRA with smaller number of feed horns is simillar to that of the DRAA .

4.Conculusion

The tradeoff study on reconfigurable multibeam antennas are performed between the DRAA and the AFRA.

In case of geostationary communications satellite applications with specified coverages, the AFRA is superior in size, complexity, and loss of the BFN.

Reference

(1) W.Bornemann, et al., IEEE Trans. Antennas and Propagation, vol.AP-33, pp1186-1193, 1985.

(2) P.Balling, et al., IEEE AP-S,International Symposium Digest, vol.2, pp510-513, June,1988.

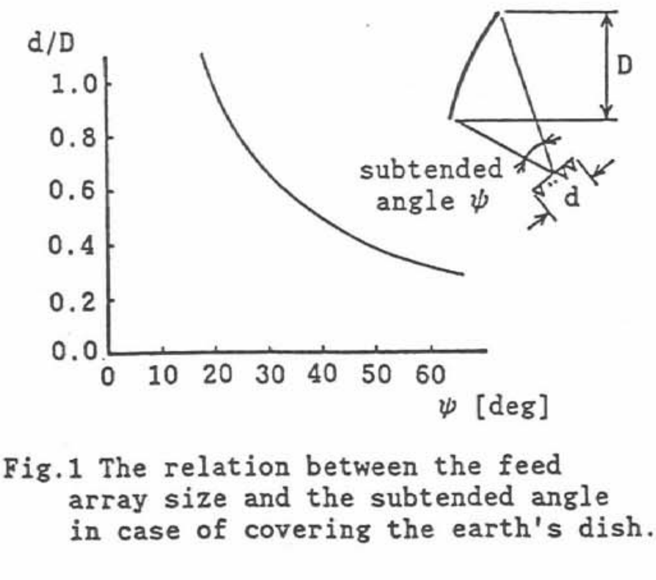

Fig.1 The relation between the feed array size and the subtended angle in case of covering the earth's dish.

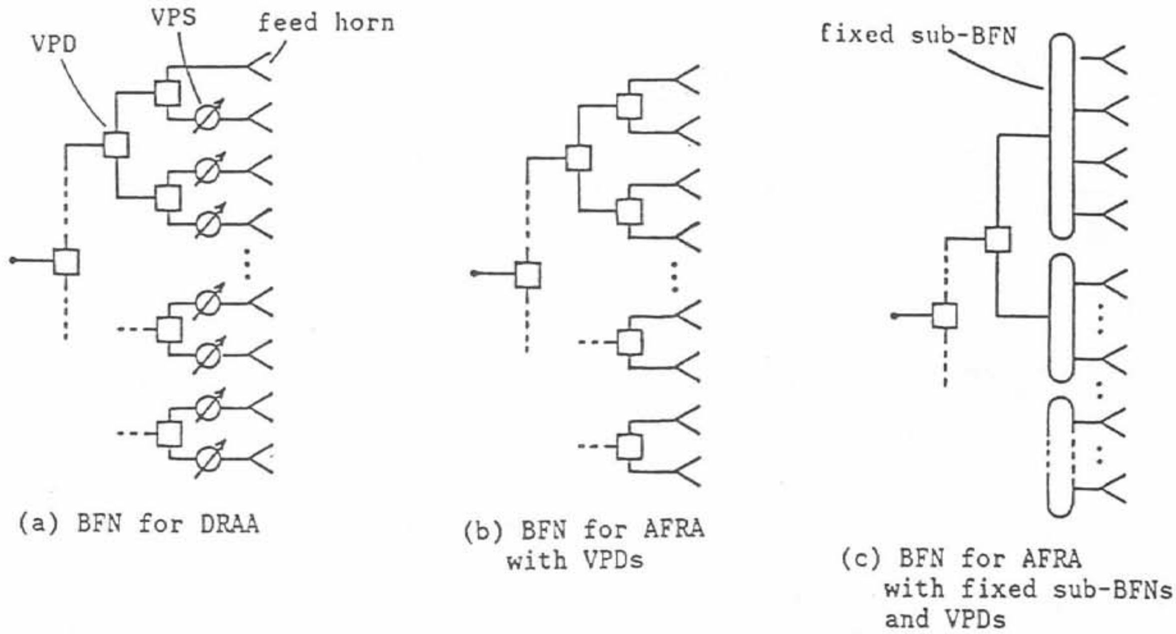

Fig.2 Block diagrams of BFN for reconfigurable antennas.

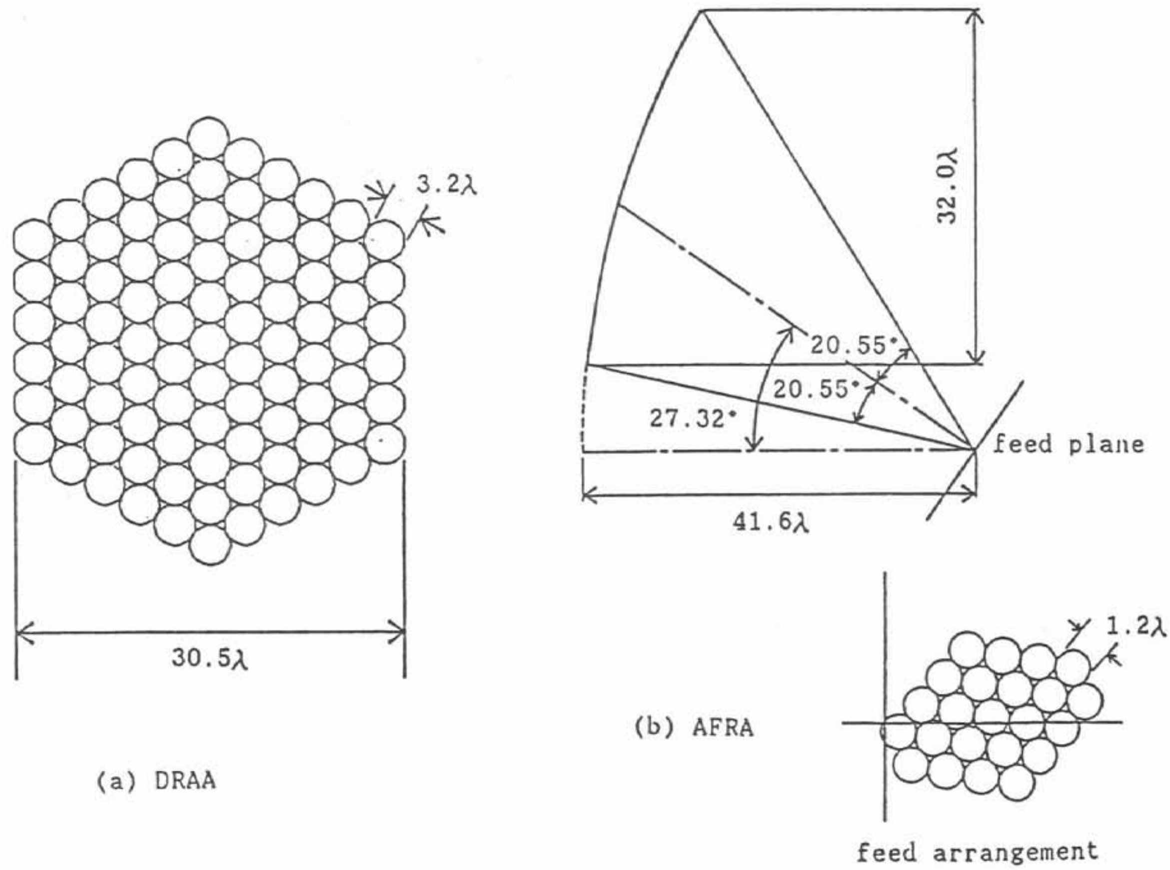

Fig.3 Reconfigurable antenna configurations.

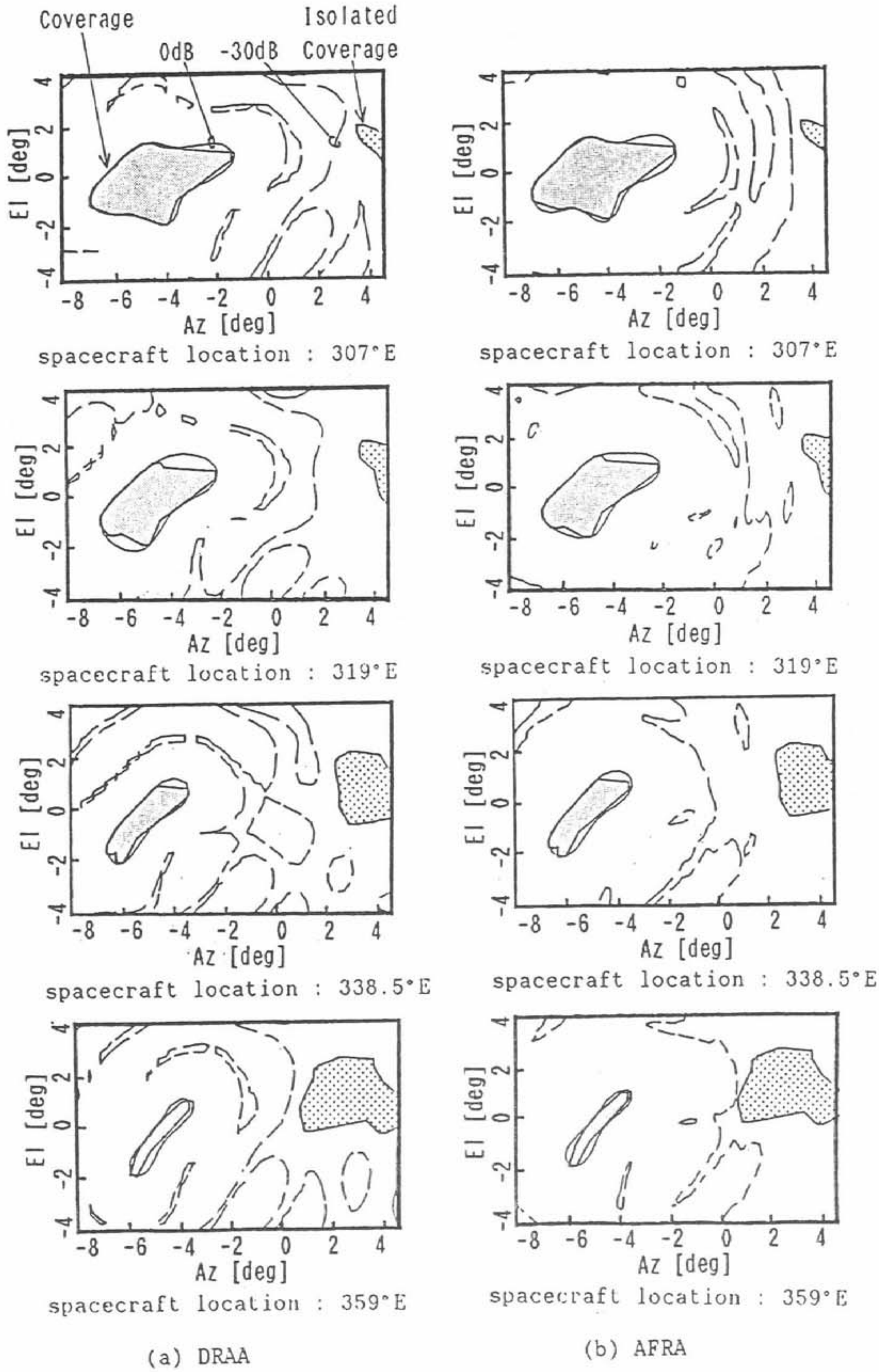

Fig.4 Comparison of calculated patterns of reconfigurable antennas for four spacecraft locations.