DEVELOPMENT OF CONICAL SCANNING TORUS ANTENNA FOR ADVANCED MICROWAVE SCANNING RADIOMETER

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1. Introduction

The Advanced Microwave Scanning Radiometer (AMSR) is a future passive microwave radiometer with electronic scanning that has capabilities of multi-frequency measurements, wide swath width, high radiometric sensitivity and high spatial resolution. The primary objectives of the AMSR are to obtain the data for the investigation on salinity of the ocean , sea surface temperature, soil moisture, ocean wind, water vapor in the atmosphere, cloud liquid content, and so on. The AMSR is planned to be provided for NASA's first Polar Platform, and will be launched in the latter half of 1990's. (1)

A conical scanning torus antenna concept has been developed for the AMSR. This antenna, which consists of a torus reflector and feed horn array arranged along the focal line of the reflector, realizes the conical scanning electronically without variation and deterioration of electrical performance. This paper presents the design concept of the conical scanning torus antenna and results of phase-A study.

2. System Requirements

General requirements of a microwave radiometer are constant incidence angle over the wide swath, multiple frequency and polarization, high spatial and temperature resolution, and so on. In order to maintain the incidence angle constant, conical scanning is required as shown in Figure 1. A mechanical rotation of parabolic reflector has been general method for the conical scanning. On the other hand, a large antenna aperture is required to achieve high spatial resolution. However, driving a large reflector may cause severe disturbance to spacecraft attitude. The AMSR was designed to employ "beam switching technique", which is a kind of electronical scanning method, to achieve these high performance requirements without disturbing the spacecraft attitude.

3. Design Description

In the AMSR antenna design, to realize electronical conical scanning multifrequency antenna, a beam switching feed with a torus reflector is selected. To improve the scan performance, the conical scanning torus antenna is proposed. The AMSR antenna consists of a torus reflector, which is a complex curved surface obtained by rotating a section of a parabola around the rotation axis, and a multifrequency feed horn array as shown in Figure 2.

As for the conical scanning torus antenna, the angle between the axis of parabola and the rotation axis of circular arc is set to be identical with the off-nadir angle as shown in Figure 2, contrary to 90 degrees for the usual torus antenna. (2)

The points P on the reflector surface are represented as follows:

$$\hat{P}(\theta, \phi) = R\hat{C} + r\hat{e}$$

where

$$\hat{C} = \sin\phi\,\hat{y} - \cos\phi\,\hat{z}$$

$$\hat{e} = \cos(\beta - \theta)\,\hat{x} + \sin(\beta - \theta)\,\hat{C}$$

$$r = 2f / (1 + \cos\theta)$$

where f : focal length of parabola

R : radius of focal line arc

β : off-nadir angle

$\hat{x}$, $\hat{y}$, $\hat{z}$: unit vectors in the direction of X, Y, Z axis, respectively

This reflector with the feed horn array arranged on or in parallel with the focal line realizes the conical scanning electrically without the variation and deterioration of elctrical performance due to the aberration.

The switching feed horn array is composed of conical horn antennas and switching circuits with equal length transmission lines for each frequency and each polarization. Figure 3 shows the diagram of the feed assembly for one channel. For the feed horn, two types of multifrequency feed horns are employed; one is for the two frequencies of 6.6GHz and 10.65GHz, and the other is for the three frequencies of 18.7GHz, 23.8GHz and 36.5GHz. And, each horn are arranged in two lines along the focal line.

4. Calculation Results

To satisfy the system requirements, aperture dimension is decided to be 6m X 2.7m. Feed array is composed of 36 conical horns for 6.6GHz and 10.65GHz, and 72 conical horns for 18.7GHz, 23.8GHz and 36.5GHz.

Table 1 shows the electrical performance for each frequency band, and Figure 4 and 5 show the example of the calculated radiation pattern at 6.6GHz and 18.7GHz, respectively. In Table 1, the beam efficiency is defined as follows:

$$\eta = \frac{\int\int_{\Omega} P(\theta, \phi)\, d\theta\, d\phi}{\int\int_{4\pi} P(\theta, \phi)\, d\theta\, d\phi} = \frac{\int\int_{\Omega} P(\theta, \phi)\, d\theta\, d\phi}{4\pi}$$

where $P(\theta, \phi)$ is the power radiated per unit angle in the direction (θ, ϕ), and Ω is the solid angle of main beam. The power in the each direction is calculated by the current distribution method.

5. Conclusion

The conical scanning torus antenna with beam switching technique is proposed. This antenna system realizes the conical scanning electronically without variation and deterioration of electrical performance.

Detailed performance analysis including a bread board model manufacturing and test will be carried out.

6. Reference

(1) K. Tachi, K. Arai, Y. Sato : "Advanced Microwave Scanning Radiometer (AMSR): Requirements and Preliminary Design Study", IEEE Trans. GE-RS, 1989

(2) R. Kreutel : "A Multiple-Beam Torus Reflector Antenna for 20/30-GHz Satellite Communications Systems", AIAA 6th CSSC, 76-302(1976)

Table 1 Antenna Performances (Preliminary)

Items	Antenna Performance				
Frequency(GHz)	6.6	10.65	18.7	23.8	36.5
Polarization	Vertical and Horizontal				
Beam Efficiency(%)	83	88	84	84	83
Beam Width(deg)(AZ X EL)	1.3X1.2	1.0X1.0	0.6X0.6	0.5X0.6	0.4X0.4
Incidence Angle(deg)	55, 58.7		50.7, 52.4		

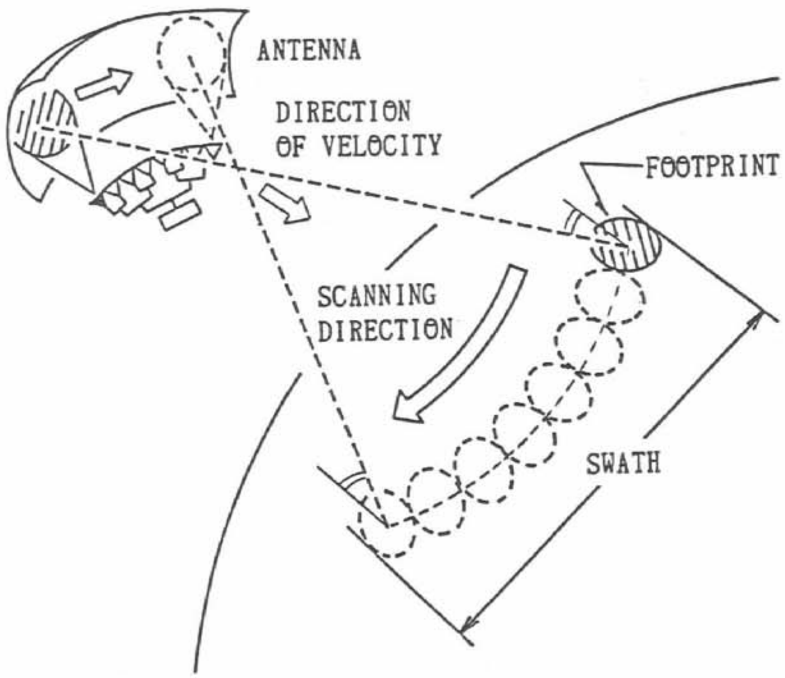


Figure 1 Conical Scanning

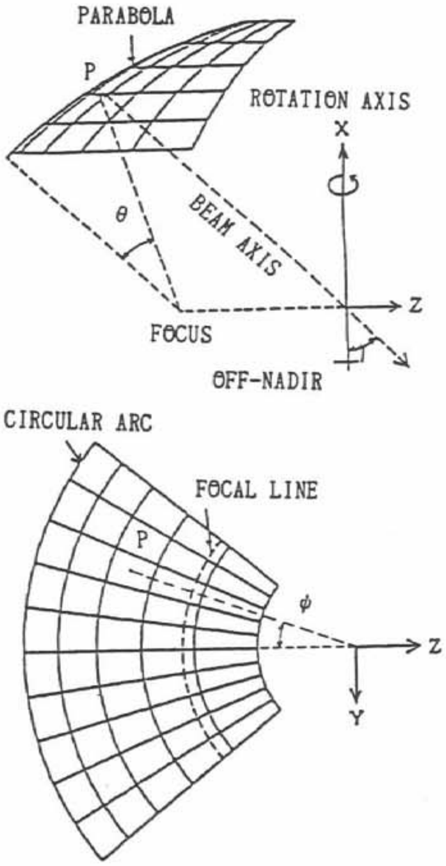
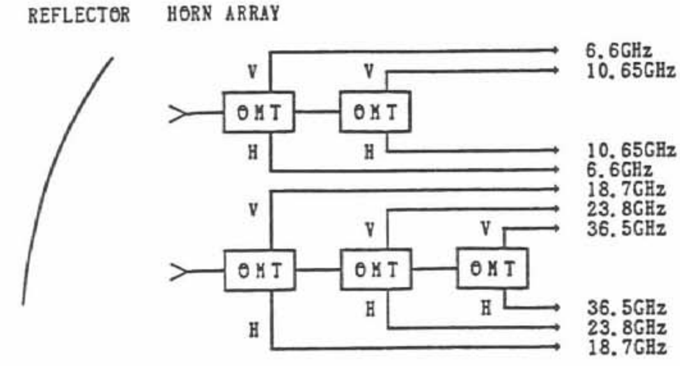


Figure 2 Conical Scanning Torus Antenna



(a) Multifrequency Feed Horn

(b) Switching Circuit

Figure 3 Feed Assembly

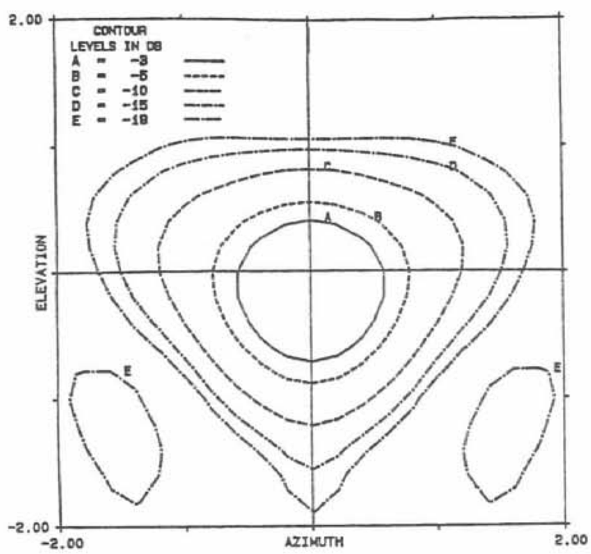


Figure 4 Beam Contour at 6.6GHz

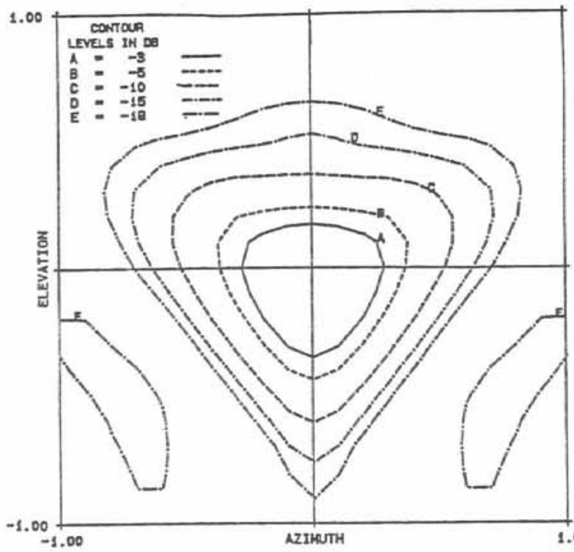


Figure 5 Beam Contour at 18.7GHz